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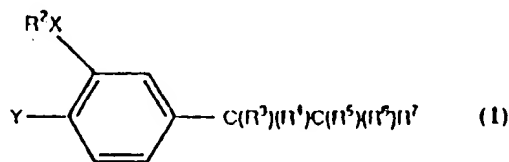
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(54) Title: TRI-SUBSTITUTED PHENYL DERIVATIVES AS PHOSPHODIESTERASE INHIBITORS



(57) Abstract

Compounds of general formula (1) are described wherein Y is a halogen atom or a group -OR¹, where R¹ is an optionally substituted alkyl group; X is -O-, -S- or -N(R²)-, where R² is a hydrogen atom or an alkyl group; R² is an optionally substituted alkyl, alkenyl, cycloalkyl or cycloalkenyl group; R³ is a hydrogen or halogen atom or an -OR³ group, where R³ is a hydrogen atom or an optionally substituted alkyl, alkenyl, alkoxyalkyl, or alkanoyl group, or a formyl, carboxamido or thiocarboxamido group; R⁴ and R⁵, which may be the same or different, is each a group -(CH₂)_nAr, where Ar is a monocyclic or bicyclic aryl group optionally containing one or more heteroatoms selected from oxygen, sulphur or nitrogen atoms and n is zero or an integer 1, 2 or 3; R⁶ is a hydrogen atom or an optionally substituted alkyl group; R⁷ is a hydrogen atom or an optionally substituted alkyl group; and the salts, solvates, hydrates and N-oxides thereof. Compounds according to the invention are potent, selective and orally active PDE IV inhibitors and are useful in the prophylaxis and treatment of asthma and other diseases.

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TRI-SUBSTITUTED PHENYL DERIVATIVES AS PHOSPHODIESTERASE INHIBITORS

- 5 This invention relates to a novel series of tri-substituted phenyl derivatives, to processes for their preparation, to pharmaceutical compositions containing them, and to their use in medicine.

10 Many hormones and neurotransmitters modulate tissue function by elevating intra-cellular levels of adenosine 3', 5'-cyclic monophosphate (cAMP). The cellular levels of cAMP are regulated by mechanisms which control synthesis and breakdown. The synthesis of cAMP is controlled by
15 adenylyl cyclase which may be directly activated by agents such as forskolin or indirectly activated by the binding of specific agonists to cell surface receptors which are coupled to adenylyl cyclase. The breakdown of cAMP is controlled by a family of phosphodiesterase (PDE) isoenzymes, which
20 also control the breakdown of guanosine 3',5'-cyclic monophosphate (cGMP). To date, seven members of the family have been described (PDE I-VII) the distribution of which varies from tissue to tissue. This suggests that specific inhibitors of PDE isoenzymes could achieve
25 differential elevation of cAMP in different tissues, [for reviews of PDE distribution, structure, function and regulation, see Beavo & Reilsnyder (1990) TIPS, 11: 150-155 and Nicholson et al (1991) TIPS, 12: 19-27].

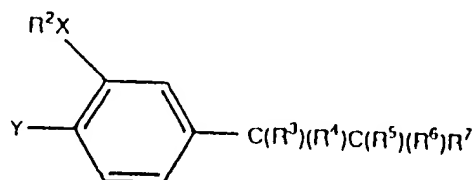
- 25 There is clear evidence that elevation of cAMP in inflammatory leukocytes leads to inhibition of their activation. Furthermore, elevation of cAMP in airway smooth muscle has a spasmolytic effect. In these tissues, PDE IV plays a major role in the hydrolysis of cAMP. It can be expected, therefore, that selective inhibitors of PDE IV would have therapeutic
30 effects in inflammatory diseases such as asthma, by achieving both anti-inflammatory and bronchodilator effects.

35 The design of PDE IV inhibitors has met with limited success to date, in that many of the potential PDE IV inhibitors which have been synthesised have lacked potency and/or have been capable of inhibiting more than one type of PDE isoenzyme in a non-selective manner. Lack of a selective

action has been a particular problem given the widespread role of cAMP *in vivo* and what is needed are potent selective PDE IV inhibitors with an inhibitory action against PDE IV and little or no action against other PDE isoenzymes.

We have now found a novel series of tri-substituted phenyl derivatives, members of which compared to known structurally similar compounds are potent inhibitors of PDE IV at concentrations at which they have little or no inhibitory action on other PDE isoenzymes. These compounds inhibit the human recombinant PDE IV enzyme and also elevate cAMP in isolated leukocytes. Certain compounds prevent inflammation in the lungs induced by carrageenan, platelet-activating factor (PAF), interleukin-5 (IL-5) or antigen challenge. These compounds also suppress the hyperresponsiveness of airway smooth muscle seen in inflamed lungs. Advantageously, compounds according to the invention have good oral activity and at orally effective doses exhibit little or none of the side-effects associated with known PDE IV inhibitors, such as rolipram. The compounds of the invention are therefore of use in medicine, especially in the prophylaxis and treatment of asthma.

Thus according to one aspect of the invention, we provide a compound of formula (1)



(1)

wherein

Y is a halogen atom or a group $-OR^1$ where R^1 is an optionally substituted alkyl group;

X is $-O-$, $-S-$ or $-N(R^8)-$, where R^8 is a hydrogen atom or an alkyl group;

R^2 is an optionally substituted alkyl, alkenyl, cycloalkyl or cycloalkenyl group;

R^3 is a hydrogen or halogen atom or an $-OR^9$ group, where R^9 is a hydrogen atom or an optionally substituted alkyl, alkenyl, alkoxyalkyl, or alkanoyl group, or a formyl, carboxamido or thiocarboxamido group;
 R^4 and R^5 , which may be the same or different, is each a group
5 $-(CH_2)_nAr$, where Ar is a monocyclic or bicyclic aryl group optionally containing one or more heteroatoms selected from oxygen, sulphur or nitrogen atoms and n is zero or an integer 1,2 or 3;
 R^6 is a hydrogen atom or an optionally substituted alkyl group;
 R^7 is a hydrogen atom or an optionally substituted alkyl group; and the
10 salts, solvates, hydrates and N-oxides thereof.

It will be appreciated that the compounds of formula (1) may have one or more chiral centres, depending on the nature of the groups R^3 , R^4 , R^5 , R^6 and R^7 . Where one or more chiral centres is present, enantiomers or
15 diastereomers may exist, and the invention is to be understood to extend to all such enantiomers, diastereomers and mixtures thereof, including racemates.

In the compounds of formula (1), when Y is a halogen atom it may be for
20 example a fluorine, chlorine, bromine or iodine atom.

When Y in the compounds of formula (1) is a group $-OR^1$, R^1 may be, for example, an optionally substituted straight or branched alkyl group, for example, an optionally substituted C_{1-6} alkyl group, such as a methyl,
25 ethyl, n-propyl or i-propyl group. Optional substituents which may be present on R^1 groups include one or more halogen atoms, e.g. fluorine, or chlorine atoms. Particular substituted alkyl groups include for example $-CH_2F$, $-CH_2Cl$, $-CHF_2$, $-CHCl_2$, $-CF_3$ or $-CCl_3$ groups.

30 Alkyl groups represented by R^2 , R^6 or R^7 in the compounds of formula (1) include optionally substituted straight or branched C_{1-6} alkyl groups, e.g. C_{1-3} alkyl groups such as methyl or ethyl groups. Optional substituents on these groups include one, two or three substituents selected from halogen atoms, e.g. fluorine, chlorine, bromine or iodine atoms, or hydroxyl or C_{1-6}
35 alkoxy e.g. C_{1-3} alkoxy such as methoxy or ethoxy groups.

Alkenyl groups represented by R^2 in the compounds of formula (1) include optionally substituted straight or branched C_{2-6} alkenyl groups such as ethenyl, propen-1-yl and 2-methylpropen-1-yl. Optional substituents include those described above in relation to the groups R^2 , R^6 and R^7 .

5

When R^2 in the compounds of formula (1) is an optionally substituted cycloalkyl or cycloalkenyl group it may be for example a C_{3-8} cycloalkyl group such as a cyclobutyl, cyclopentyl or cyclohexyl group or a C_{3-8} cycloalkenyl group containing for example one or two double bonds such as a 2-cyclobuten-1-yl, 2-cyclopenten-1-yl, 3-cyclopenten-1-yl, 2,4-cyclopentadien-1-yl, 2-cyclohexen-1-yl, 3-cyclohexen-1-yl, 2,4-cyclohexadien-1-yl or 3,5-cyclohexadien-1-yl group, each cycloalkyl or cycloalkenyl group being optionally substituted by one, two or three substituents selected from halogen atoms, e.g. fluorine, chlorine, bromine or iodine atoms, straight or branched C_{1-6} alkyl e.g. C_{1-3} alkyl such as methyl or ethyl, hydroxyl or C_{1-6} alkoxy e.g. C_{1-3} alkoxy such as methoxy or ethoxy groups.

Alkyl groups represented by R^8 in compounds of formula (1) include straight or branched C_{1-6} alkyl groups, e.g. C_{1-3} alkyl groups such as methyl or ethyl groups.

25

When the group R^3 in compounds of formula (1) is a halogen atom it may be for example a fluorine, chlorine, bromine or iodine atom.

When the group R^3 in compounds of formula (1) is an $-OR^9$ group it may be for example a hydroxyl group; or a group $-OR^9$ where R^9 is an optionally substituted straight or branched C_{1-6} alkyl group, e.g. a C_{1-3} alkyl group such as a methyl or ethyl group, a C_{2-6} alkenyl group such as an ethenyl or 2-propen-1-yl group, a C_{1-3} alkoxy C_{1-3} alkyl group such as a methoxymethyl, ethoxymethyl or ethoxyethyl group, a C_{1-6} alkanoyl, e.g. C_{1-3} alkanoyl such as acetyl group, or a formyl $[HC(O)-]$ or a carboxamido $(CONR^{11}R^{12})$ or thiocarboxamido $(CSNR^{11}R^{12})$ group, where R^{11} and R^{12} in each instance may be the same or different and is each a hydrogen atom or an optionally substituted straight or branched C_{1-6} alkyl, e.g. C_{1-3} alkyl group such as a methyl or ethyl group. Optional

35

it may be a 2-thienyl or 3-thienyl group, and, similarly, when it is a furyl group it may be a 2-furyl or 3-furyl group.

When in compounds of formula (1) the Ar group is a nitrogen-containing heterocycle it may be possible to form quaternary salts, for example N-alkyl quaternary salts and the invention is to be understood to extend to such salts. Thus for example when the group Ar is a pyridyl group, pyridinium salts may be formed, for example N-alkylpyridinium salts such as N-methylpyridinium.

10

The aryl or heteroaryl groups represented by Ar in compounds of formula (1) may each optionally be substituted by one, two, three or more substituents R^{10} . The substituent R^{10} may be selected from an atom or group R^{13} or $-Alk^1(R^{13})_m$ wherein R^{13} is a halogen atom, or an amino ($-NH_2$), substituted amino, nitro, cyano, hydroxyl ($-OH$), substituted hydroxyl, cycloalkoxy, formyl $[HC(O)-]$, carboxyl ($-CO_2H$), esterified carboxyl, thiol ($-SH$), substituted thiol, $-C(O)Alk^1$, $-SO_3H$, $-SO_2Alk^1$, $-SO_2NH_2$, $-SO_2NHAlk^1$, $-SO_2N[Alk^1]_2$, $-CONH_2$, $-CONHAlk^1$, $-CON[Alk^1]_2$, $-NHSO_2H$, $-NHSO_2Alk^1$, $-N[SO_2Alk^1]_2$, $-NHSO_2NH_2$, $-NHSO_2NHAlk^1$, $-NHSO_2N[Alk^1]_2$, $-NHC(O)Alk^1$, or $-NHC(O)OAlk^1$ group; Alk^1 is a straight or branched C_{1-6} alkylene, C_{2-6} alkenylene, or C_{2-6} alkynylene chain optionally interrupted by one, two, or three $-O-$, or $-S-$ atoms or $-S(O)_p-$, [where p is an integer 1 or 2] or $-N(R^8)-$ groups; and m is zero or an integer 1, 2 or 3.

25

When in the group $-Alk^1(R^{13})_m$ m is an integer 1, 2 or 3, it is to be understood that the substituent or substituents R^{13} may be present on any suitable carbon atom in $-Alk^1$. Where more than one R^{13} substituent is present these may be the same or different and may be present on the same or different carbon atom in Alk^1 . Clearly, when m is zero and no substituent R^{13} is present or when Alk^1 forms part of a group such as $-SO_2Alk^1$ the alkylene, alkenylene or alkynylene chain represented by Alk^1 becomes an alkyl, alkenyl or alkynyl group.

30

35 When R^{13} is a substituted amino group it may be a group $-NH-[Alk^1(R^{13a})_m]$ [where Alk^1 and m are as defined above and R^{13a} is as defined above for

Particularly useful atoms or groups represented by R^{10} include fluorine, chlorine, bromine or iodine atoms, or C_{1-6} alkyl, e.g. methyl or ethyl, C_{1-6} alkylamino, e.g. methylamino or ethylamino, C_{1-6} hydroxyalkyl, e.g. hydroxymethyl or hydroxyethyl, C_{1-6} alkylthiol e.g. methylthiol or ethylthiol, C_{1-6} alkoxy, e.g. methoxy or ethoxy, C_{5-7} cycloalkoxy, e.g. cyclo-pentyloxy, halo C_{1-6} alkyl, e.g. trifluoromethyl, C_{1-6} alkylamino, e.g. methylamino or ethylamino, amino ($-NH_2$), amino C_{1-6} alkyl, e.g. aminomethyl or aminoethyl, C_{1-6} dialkylamino, e.g. dimethylamino or diethylamino, nitro, cyano, hydroxyl ($-OH$), formyl [$HC(O)-$], carboxyl ($-CO_2H$), $-CO_2Alk^2$ [where Alk^2 is as defined above], C_{1-6} alkanoyl e.g. acetyl, thiol ($-SH$), thio C_{1-6} alkyl, e.g. thiomethyl or thioethyl, sulphonyl ($-SO_3H$), C_{1-6} alkylsulphonyl, e.g. methylsulphonyl, aminosulphonyl ($-SO_2NH_2$), C_{1-6} alkylaminosulphonyl, e.g. methylaminosulphonyl or ethylaminosulphonyl, C_{1-6} dialkylaminosulphonyl, e.g. dimethylaminosulphonyl or diethylaminosulphonyl, carboxamido ($-CONH_2$), C_{1-6} alkylaminocarbonyl, e.g. methylaminocarbonyl or ethylaminocarbonyl, C_{1-6} dialkylaminocarbonyl, e.g. dimethylaminocarbonyl or diethylaminocarbonyl, sulphonylamino ($-NH SO_2H$), C_{1-6} alkylsulphonylamino, e.g. methylsulphonylamino or ethylsulphonylamino, C_{1-6} dialkylsulphonylamino, e.g. dimethylsulphonylamino or diethylsulphonylamino, aminosulphonylamino ($-NH SO_2NH_2$), C_{1-6} alkylaminosulphonylamino, e.g. methylaminosulphonylamino or ethylaminosulphonylamino, C_{1-6} dialkylaminosulphonylamino, e.g. dimethylaminosulphonylamino or diethylaminosulphonylamino, C_{1-6} alkanoylamino, e.g. acetylamino, C_{1-6} alkanoylamino C_{1-6} alkyl, e.g. acetylaminomethyl or C_{1-6} alkoxycarbonylamino, e.g. methoxycarbonylamino, ethoxycarbonylamino or t-butoxycarbonylamino groups.

Where desired, two R^{10} substituents may be linked together to form a cyclic group such as a cyclic ether, e.g. a C_{2-6} alkylenedioxy group such as ethylenedioxy.

It will be appreciated that where two or more R^{10} substituents are present, these need not necessarily be the same atoms and/or groups. The R^{10} substituents may be present at any ring carbon atom away from that attached to the rest of the molecule of formula (1). Thus, for example, in phenyl groups represented by Ar any substituent may be present at the 2-,

3-, 4-, 5- or 6- positions relative to the ring carbon atom attached to the remainder of the molecule.

5 In the compounds of formula (1), when an ester group is present, for example a group $-\text{CO}_2\text{Alk}^2$ this may advantageously be a metabolically labile ester.

10 The presence of certain substituents in the compounds of formula (1) may enable salts of the compounds to be formed. Suitable salts include pharmaceutically acceptable salts, for example acid addition salts derived from inorganic or organic acids, and salts derived from inorganic and organic bases.

15 Acid addition salts include hydrochlorides, hydrobromides, hydroiodides, alkylsulphonates, e.g. methanesulphonates, ethanesulphonates, or isethionates, arylsulphonates, e.g. p-toluenesulphonates, besylates or napsylates, phosphates, sulphates, hydrogen sulphates, acetates, trifluoroacetates, propionates, citrates, maleates, fumarates, malonates, succinates, lactates, oxalates, tartrates and benzoates.

20 Salts derived from inorganic or organic bases include alkali metal salts such as sodium or potassium salts, alkaline earth metal salts such as magnesium or calcium salts, and organic amine salts such as morpholine, piperidine, dimethylamine or diethylamine salts.

25 Particularly useful salts of compounds according to the invention include pharmaceutically acceptable salts, especially acid addition pharmaceutically acceptable salts.

30 In the compounds of formula (1), the group Y is preferably an $-\text{OR}^1$ group, especially where R^1 is an optionally substituted ethyl group or, especially, an optionally substituted methyl group. Especially useful substituents which may be present on R^1 groups include one, two or three fluorine or chlorine atoms.

35 The group X in compounds of formula (1) is preferably $-\text{O}-$.

R^{13} but is not a substituted amino, a substituted hydroxyl or a substituted thiol group] or a group $-N[Alk^1(R^{13a})_m]_2$ wherein each $-Alk^1(R^{13a})_m$ group is the same or different.

- 5 When R^{13} is a halogen atom it may be for example a fluorine, chlorine, bromine, or iodine atom.

When R^{13} is a cycloalkoxy group it may be for example a C_{5-7} cycloalkoxy group such as a cyclopentyloxy or cyclohexyloxy group.

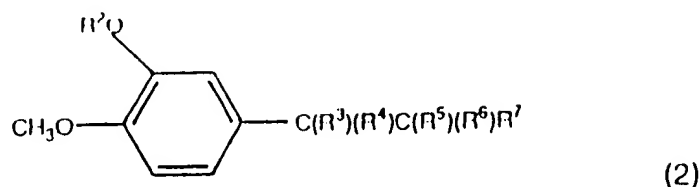
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When R^{13} is a substituted hydroxyl or substituted thiol group it may be a group $-OAlk^1(R^{13a})_m$ or $-SAlk^1(R^{13a})_m$ respectively, where Alk^1 , R^{13a} and m are as just defined.

- 15 Esterified carboxyl groups represented by the group R^{13} include groups of formula $-CO_2Alk^2$ wherein Alk^2 is a straight or branched, optionally substituted C_{1-8} alkyl group such as a methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl, s-butyl or t-butyl group; a C_{6-12} aryl C_{1-8} alkyl group such as an optionally substituted benzyl, phenylethyl, phenylpropyl, 1-naphthylmethyl or 2-naphthylmethyl group; a C_{6-12} aryl group such as an optionally substituted phenyl, 1-naphthyl or 2-naphthyl group; a C_{6-12} aryloxy C_{1-8} alkyl group such as an optionally substituted phenyloxymethyl, phenyloxyethyl, 1-naphthyloxymethyl, or 2-naphthyloxymethyl group; an optionally substituted C_{1-8} alkanoyloxy C_{1-8} alkyl group, such as a pivaloyloxymethyl, propionyloxyethyl or propionyloxypropyl group; or a C_{6-12} aroxyloxy C_{1-8} alkyl group such as an optionally substituted benzoyloxyethyl or benzoyloxypropyl group. Optional substituents present on the Alk^2 group include R^{10} substituents described above.

- 20
25
30 When Alk^1 is present in or as a substituent R^{10} it may be for example a methylene, ethylene, n-propylene, i-propylene, n-butylene, i-butylene, s-butylene, t-butylene, ethenylene, 2-propenylene, 2-butenylene, 3-butenylene, ethynylene, 2-propynylene, 2-butyrylene or 3-butyrylene chain, optionally interrupted by one, two, or three -O- or -S-, atoms or
35 -S(O)-, -S(O)₂- or -N(R^0)- groups.

A particularly useful group of compounds of formula (1) has the formula (2):



5

where R² is an optionally substituted cycloalkyl group; R³, R⁴, R⁵, R⁶ and R⁷ are as defined for formula (1); and the salts, solvates, hydrates and N-oxides thereof.

10 In the compounds of formulae (1) or (2) R² is preferably an optionally substituted methyl or cyclopentyl group. In particular, R² is a cyclopentyl group.

15 The group R³ in compounds of formulae (1) or (2) is preferably a hydrogen atom.

In compounds of formulae (1) or (2) the group R⁶ is preferably a methyl group, or especially a hydrogen atom.

20 The group R⁷ in compounds of formulae (1) or (2) is preferably a methyl group, or especially a hydrogen atom.

25 In one preference, R⁶ and R⁷ in compounds of formula (1) is each a methyl group. In another preference, one of R⁶ or R⁷ is a methyl group and the other is a hydrogen atom. In general, however, R⁶ and R⁷ is each especially a hydrogen atom.

The groups R⁴ and R⁵ in compounds of formulae (1) or (2) is each, independently, preferably a -CH₂Ar group, or, especially, an -Ar group.

30

Particularly useful R⁴ or R⁵ groups in the compounds of formulae (1) or (2) include those R⁴ or R⁵ groups in which Ar is a monocyclic aryl group optionally containing one or more heteroatoms selected from oxygen,

such as a mono- or disubstituted 2-pyridyl, 3-pyridyl or especially 4-pyridyl group substituted by one or two atoms or groups R^{10} as defined above, in particular one or two halogen atoms such as fluorine or chlorine atoms, or methyl, methoxy, hydroxyl or nitro groups. Particularly useful pyridyl groups of these types are 3-monosubstituted-4-pyridyl or 3,5-disubstituted-4-pyridyl, or 2- or 4-monosubstituted-3-pyridyl or 2,4-disubstituted-3-pyridyl groups.

A particularly useful group of compounds according to the invention has the formula (2) wherein R^3 , R^6 and R^7 is each a hydrogen atom and R^2 , R^4 and R^5 are as defined for formula (1); and the salts, solvates, hydrates and N-oxides thereof. Compounds of this type in which R^2 is a cycloalkyl or substituted cycloalkyl group, especially a substituted cyclopentyl or in particular a cyclopentyl group are particularly useful. In this group of compounds, R^4 is preferably a monocyclic aryl group, particularly a phenyl or substituted phenyl group or R^4 is a six-membered nitrogen-containing monocyclic heteroaryl group, particularly a pyridyl or substituted pyridyl group and R^5 is a six-membered nitrogen-containing monocyclic heteroaryl group, especially a pyridyl or substituted pyridyl group in particular a 4-pyridyl or substituted 4-pyridyl group.

Particularly useful compounds according to the invention are:

- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-furyl)ethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-thienyl)ethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-3-methylimidazole;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-fluorophenyl)ethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-trifluoromethylphenyl)ethyl]pyridine;

- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-methoxyphenyl-ethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-methoxyphenyl-ethyl)]pyridine;
- 5 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-methylphenyl-ethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(3-methylphenyl-ethyl)]pyridine;
- 10 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(3-cyclopentyloxy-4-methoxyphenyl)ethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-3,5-dichloropyridine;
- (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- 15 (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]aniline;
- (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzoic acid;
- (±) Ethyl N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]carbamate;
- 20 (±) N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]N'-ethylurea;
- (±) N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]acetamide;
- 25 (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyrimidine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-hydroxymethylphenyl)ethyl]pyridine;
- 30 (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzamide;
- (±) Ethyl-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-phenylethyl)benzoate];
- 35 (±) N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]methanesulphonamide; or

the resolved enantiomers thereof; and the salts, solvates, hydrates and N-oxides thereof.

The above specifically mentioned compounds exist in two enantiomeric forms. Each enantiomer is useful, as are mixtures of both enantiomers.

Compounds according to the invention are selective and potent inhibitors of PDE IV. The ability of the compounds to act in this way may be simply determined by the tests described in the Examples hereinafter.

10

The compounds according to the invention are thus of particular use in the prophylaxis and treatment of human diseases where an unwanted inflammatory response or muscular spasm (for example bladder or alimentary smooth muscle spasm) is present and where the elevation of cAMP levels may be expected to prevent or alleviate the inflammation and relax muscle.

15

Particular uses to which the compounds of the invention may be put include the prophylaxis and treatment of asthma, especially inflamed lung associated with asthma, cystic fibrosis, or in the treatment of inflammatory airway disease, chronic bronchitis, eosinophilic granuloma, psoriasis and other benign and malignant proliferative skin diseases, endotoxic shock, septic shock, ulcerative colitis, Crohn's disease, reperfusion injury of the myocardium and brain, inflammatory arthritis, chronic glomerulonephritis, atopic dermatitis, urticaria, adult respiratory distress syndrome, diabetes insipidus, allergic rhinitis, allergic conjunctivitis, vernal conjunctivitis, arterial restenosis and arteriosclerosis.

25

Compounds of the invention also suppress neurogenic inflammation through elevation of cAMP in sensory neurones. They are, therefore, analgesic, anti-tussive and anti-hyperalgesic in inflammatory diseases associated with irritation and pain.

30

Compounds according to the invention may also elevate cAMP in lymphocytes and thereby suppress unwanted lymphocyte activation in

35

immune-based diseases such as rheumatoid arthritis, ankylosing spondylitis, transplant rejection and graft versus host disease.

5 Compounds according to the invention have also been found to reduce gastric acid secretion and therefore can be used to treat conditions associated with hypersecretion.

10 Compounds of the invention suppress cytokine synthesis by inflammatory cells in response to immune or infectious stimulation. They are, therefore, useful in the treatment of bacterial, fungal or viral induced sepsis and septic shock in which cytokines such as tumour necrosis factor (TNF) are key mediators. Also compounds of the invention suppress inflammation and pyrexia due to cytokines and are, therefore, useful in the treatment of inflammation and cytokine-mediated chronic tissue degeneration which
15 occurs in diseases such as rheumatoid or osteo-arthritis.

Over-production of cytokines such as TNF in bacterial, fungal or viral infections or in diseases such as cancer, leads to cachexia and muscle wasting. Compounds of the invention ameliorate these symptoms with a
20 consequent enhancement of quality of life.

Compounds of the invention also elevate cAMP in certain areas of the brain and thereby counteract depression and memory impairment.

25 Compounds of the invention suppress cell proliferation in certain tumour cells and can be used, therefore, to prevent tumour growth and invasion of normal tissues.

30 For the prophylaxis or treatment of disease the compounds according to the invention may be administered as pharmaceutical compositions, and according to a further aspect of the invention we provide a pharmaceutical composition which comprises a compound of formula (1) together with one or more pharmaceutically acceptable carriers, excipients or diluents.

Pharmaceutical compositions according to the invention may take a form suitable for oral, buccal, parenteral, nasal, topical or rectal administration, or a form suitable for administration by inhalation or insufflation.

- 5 For oral administration, the pharmaceutical compositions may take the form of, for example, tablets, lozenges or capsules prepared by conventional means with pharmaceutically acceptable excipients such as binding agents (e.g. pregelatinised maize starch, polyvinylpyrrolidone or hydroxypropyl methylcellulose); fillers (e.g. lactose, microcrystalline
10 cellulose or calcium hydrogen phosphate); lubricants (e.g. magnesium stearate, talc or silica); disintegrants (e.g. potato starch or sodium glycollate); or wetting agents (e.g. sodium lauryl sulphate). The tablets may be coated by methods well known in the art. Liquid preparations for oral administration may take the form of, for example, solutions, syrups or
15 suspensions, or they may be presented as a dry product for constitution with water or other suitable vehicle before use. Such liquid preparations may be prepared by conventional means with pharmaceutically acceptable additives such as suspending agents, emulsifying agents, non-aqueous vehicles and preservatives. The preparations may also contain buffer
20 salts, flavouring, colouring and sweetening agents as appropriate.

Preparations for oral administration may be suitably formulated to give controlled release of the active compound.

- 25 For buccal administration the compositions may take the form of tablets or lozenges formulated in conventional manner.

- The compounds for formula (1) may be formulated for parenteral administration by injection e.g. by bolus injection or infusion. Formulations
30 for injection may be presented in unit dosage form, e.g. in glass ampoule or multi dose containers, e.g. glass vials. The compositions for injection may take such forms as suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilising, preserving and/or dispersing agents.
35 Alternatively, the active ingredient may be in powder form for constitution with a suitable vehicle, e.g. sterile pyrogen-free water, before use.

In addition to the formulations described above, the compounds of formula (1) may also be formulated as a depot preparation. Such long acting formulations may be administered by implantation or by intramuscular injection.

For nasal administration or administration by inhalation, the compounds for use according to the present invention are conveniently delivered in the form of an aerosol spray presentation for pressurised packs or a nebuliser, with the use of suitable propellant, e.g. dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas or mixture of gases.

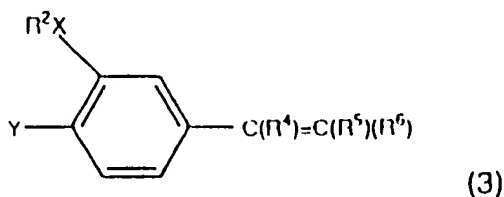
The compositions may, if desired, be presented in a pack or dispenser device which may contain one or more unit dosage forms containing the active ingredient. The pack or dispensing device may be accompanied by instructions for administration.

The quantity of a compound of the invention required for the prophylaxis or treatment of a particular inflammatory condition will vary depending on the compound chosen, and the condition of the patient to be treated. In general, however, daily dosages may range from around 100ng/kg to 100mg/kg, e.g. around 0.01mg/kg to 40mg/kg body weight for oral or buccal administration, from around 10ng/kg to 50mg/kg body weight for parenteral administration and around 0.05mg to around 1000mg e.g. around 0.5mg to around 1000mg for nasal administration or administration by inhalation or insufflation.

The compounds according to the invention may be prepared by the following processes. The symbols Y, R², R³, R⁴, R⁵, R⁶, R⁷ and X, when used in the formulae below are to be understood to represent those groups described above in relation to formula (1) unless otherwise indicated. In the reactions described below it may be necessary to protect reactive functional groups, for example hydroxy, amino, thio, or carboxy groups, where these are desired in the final product, to avoid their unwanted participation in the reactions. Conventional protecting groups

may be used in accordance with standard practice [see, for example, Green, T. W. in "Protective Groups in Organic Synthesis" John Wiley and Sons, 1981.] It may be that deprotection will form the last step in the synthesis of compounds of formula (1). Thus, in one example, compounds
5 of formula (1) wherein R^4 and/or R^5 contains a carboxylic acid group may be prepared by deprotecting the corresponding compound wherein R^4 and/or R^5 contains a protected carboxyl group, such as an oxazolinyl group, e.g. 4,4-dimethyl-2-oxazolinyl, in the presence of a base, e.g. sodium hydroxide, in an acid solvent e.g. aqueous hydrochloric acid, at an
10 elevated temperature, e.g. the reflux temperature.

Thus according to a further aspect of the invention, a compound of formula (1) wherein R^3 and R^7 is each a hydrogen atom may be prepared by
15 hydrogenation of a compound of formula (3):



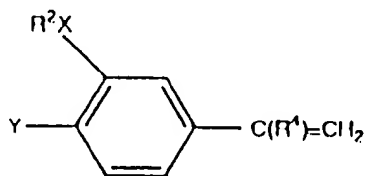
The hydrogenation may be performed using for example hydrogen in the presence of a catalyst. Suitable catalysts include metals such as
20 platinum or palladium, optionally supported on an inert carrier such as carbon or calcium carbonate; nickel e.g. Raney nickel, or rhodium. The reaction may be performed in a suitable solvent, for example an alcohol such as methanol or ethanol, an ether such as tetrahydrofuran or dioxane or an ester such as ethyl acetate, optionally in the presence of a base, for
25 example a tertiary organic base such as triethylamine, at for example ambient temperature.

Alternatively, the reaction may be accomplished by transfer hydrogenation using an organic hydrogen donor and a transfer agent. Suitable hydrogen
30 donors include for example acids, such as formic acid, formates, e.g. ammonium formate, alcohols, such as benzyl alcohol or ethylene glycol, hydrazine, and cycloalkenes such as cyclohexene or cyclohexadiene. The transfer agent may be for example a transition metal, for example

palladium or platinum, optionally supported on an inert carrier as discussed above, nickel e.g. Raney nickel, ruthenium, e.g. tris(triphenylphosphine)ruthenium chloride or copper. The reaction may generally be performed at an ambient or elevated temperature, optionally
 5 in the presence of a solvent, for example an alcohol such as ethanol or an acid such as acetic acid.

Intermediates of formula (3) may be prepared using a Horner-Wadsworth-Emmons approach by reaction of a ketone of formula (6) [described
 10 hereinafter] with a phosphonate $R^5CH_2PO(OAlk)_2$, where Alk is a C_{1-4} alkyl group such as a methyl group, in the presence of a base such as sodium hydride. The phosphonates for use in this reaction may be prepared by conventional methods, for example by reaction of a compound R^5CH_2L , where L is a leaving group such as a chlorine atom
 15 with a phosphine $P(OAlk)_3$.

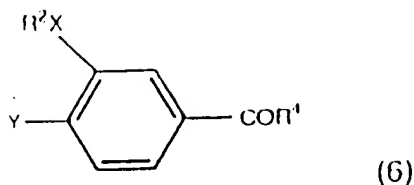
In another process for the preparation of intermediates of formula (3), an alkene of formula (4):



(4)

may be coupled in a Heck reaction with an organopalladium compound derived from a compound R^5Ial [where Hal is a halogen atom such as a bromine atom] and a palladium salt such as palladium acetate in the
 25 presence of a phosphine such as tri-*o*-tolyl phosphine and a base such as triethylamine at an elevated temperature and pressure.

Intermediate alkenes of formula (4) may be obtained by reaction of a corresponding ketone of formula (6) (described hereinafter) using a Wittig
 30 reaction employing a phosphonium salt such as methyltriphenylphosphonium bromide in the presence of a base such as *n*-butyllithium and an inert solvent such as tetrahydrofuran at, for example, $0^\circ C$ to ambient temperature.



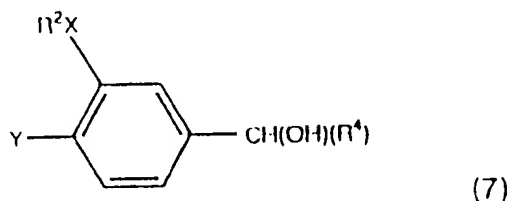
with an organometallic reagent R^5R^6CHZ , where Z is a metal atom.

- 5 Metal atoms represented by Z include, for example, a lithium atom.

The reaction may be performed in a solvent such as an ether, e.g. a cyclic ether such as tetrahydrofuran, at a low temperature e.g. around -70°C to ambient temperature. This reaction is particularly suitable for the
 10 preparation of compounds of formula (1) wherein R^5 is an electron deficient group such as a 2- or 4-pyridyl group.

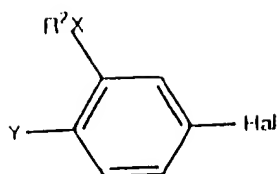
- Reagents R^5R^6CHZ are either known compounds or may be prepared, preferably in situ during the above process, by reaction of a compound
 15 AlkCH_2Z [where Alk is an alkyl group such as a n-propyl group] with a compound $R^5R^6CH_2$ where necessary in the presence of a base such as an amine e.g. diisopropylamine using the above-mentioned conditions.

- 20 Ketones of formula (6) may be prepared by oxidation of a corresponding alcohol of formula (7):



- 25 using an oxidising agent such as manganese dioxide in a solvent such as dichloromethane at ambient temperature.

Alternatively, ketones of formula (6) may be prepared by reaction of a halide of formula (8):

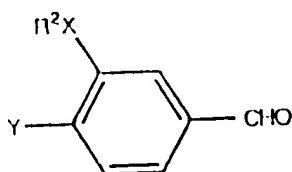


(8)

[where Hal is a halogen atom such as a bromine or chlorine atom] by
halogen-metal exchange with a base such as n-butyllithium followed by
reaction with a nitrile R⁴CN, an acid chloride R⁴COCl or an ester
R⁴CO₂Alk (where Alk is an alkyl group, e.g. a methyl group), in a solvent
such as tetrahydrofuran at a low temperature, e.g. around -70°C, and
subsequent treatment with an acid such as hydrochloric acid at e.g. -20°C
to ambient temperature.

10

Alcohols of formula (7) may be prepared by reaction of an aldehyde of
formula (9):



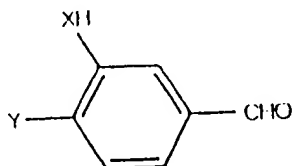
(9)

with an organometallic compound, such as an organolithium compound
R⁴Li, or a Grignard reagent R⁴MgBr, in a solvent, such as tetrahydrofuran,
at a low temperature, e.g. around -55°C to 0°C.

15

Aldehydes of formula (9) may be prepared by alkylation of a
corresponding compound of formula (10):

20



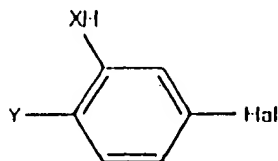
(10)

using a compound R²Hal [where Hal is as previously defined] using the
reagents and conditions described hereinafter for the alkylation of
intermediates of formula (10).

25

Intermediates of formula (10) are either known compounds or may be prepared from known starting materials by methods analogous to those used for the preparation of the known compounds.

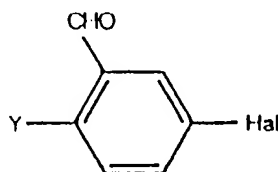
- 5 Halides of formula (8) may be prepared by alkylation of a compound of formula (11):



(11)

- 10 using the reagents and conditions discussed above in relation to the alkylation of aldehydes of formula (10).

Halides of formula (11) where X is -O- may be prepared by oxidation of an aldehyde of formula (12):



(12)

15

using an oxidising agent such as 3-chloroperoxybenzoic acid in a halogenated hydrocarbon such as chloroform at a temperature from around 0°C to room temperature.

20

Aldehydes of formula (12) and halides of formula (11) where X is -S- or -N(R⁸)- are either known compounds or may be prepared from known starting materials by methods analogous to those used for the preparation of the known compounds.

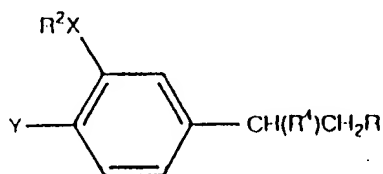
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In yet another process according to the invention, compounds of formula (1) wherein R³, R⁶ and R⁷ is each a hydrogen atom may be prepared by decarboxylation of an acid of formula (13):

Compounds of formula (14) may be obtained by reacting an aldehyde of formula (9) with an ester or nitrile $R^5CH_2R^{14}$ in an acid solvent, such as acetic acid, at an elevated temperature, for example the reflux temperature, in the presence of a base, such as ammonium acetate.

5

In a further process according to the invention a compound of formula (1) wherein R^3 , R^6 and R^7 is each a hydrogen atom and R^5 is a heteroaryl group may be generally prepared by cyclisation of a compound of formula (15):



10

(15)

15

where R is a carboxylic acid $[-CO_2H]$ group or a reactive derivative thereof; or a nitrile $[-CN]$ or an imine salt with a bifunctional reagent $W^1R^{5a}W^2$ and, where necessary, a compound $R^{5b}W^3$ [where W^1 , W^2 and W^3 , which may be the same or different, is each a reactive functional group or a protected derivative thereof; and R^{5a} and R^{5b} are components of the heteroaryl group R^5 such that when added together with W^1 , W^2 and W^3 to the group R in compounds of formula (15) the resulting group $-RW^1R^{5a}W^2$ or $-RW^1R^{5a}W^2R^{5b}W^3$ constitutes the heteroaryl group R^5].

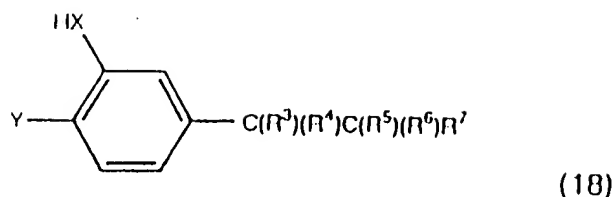
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25

Reactive derivatives of carboxylic acids for use in this reaction include acid halides, (e.g. acid chlorides), amides, including thioamides, or esters, including thioesters. Imine salts include for example salts of formula [e.g. $-C(OAlk)=NH_2^+A^-$, where Alk is a C_{1-4} alkyl group and A^- is a counterion e.g. a chloride ion].

30

In this general reaction the reactive functional groups represented by W^1 , W^2 or W^3 may be any suitable carbon, nitrogen, sulphur or oxygen nucleophiles. Particular examples include simple nucleophiles such as carbanions [e.g. generated by the coupling of an alkyl group with an organometallic compound], amino, thiol and hydroxyl groups.



using a reagent R^2L , where L is a leaving group.

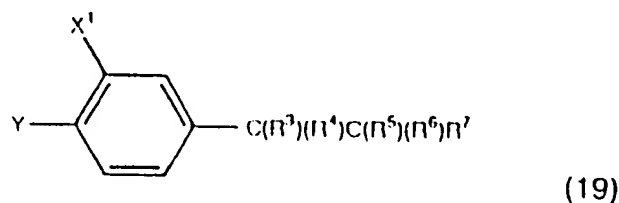
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Leaving groups represented by L include halogen atoms such as iodine or chlorine or bromine atoms or sulphonyloxy groups such as arylsulphonyloxy groups, e.g. p-toluenesulphonyloxy.

- 10 The alkylation reaction may be carried out in the presence of a base, e.g. an inorganic base such as a carbonate, e.g. caesium or potassium carbonate, an alkoxide, e.g. potassium-t-butoxide, or a hydride, e.g. sodium hydride, in a dipolar aprotic solvent such as an amide, e.g. a substituted amide such as dimethylformamide or an ether, e.g. a cyclic
- 15 ether such as tetrahydrofuran, at ambient temperature or above e.g. around 40°C to 50°C.

Intermediates of formula (18) may be obtained from the corresponding protected compound of formula (19):

20



- wherein X^1 is a protected hydroxy, thio or amino group using conventional procedures [see Green, T. W. *ibid*]. Thus, for example, where X is a t-butyltrimethylsilyloxy group, the required hydroxyl group may be obtained
- 25 by treatment of the protected intermediate with tetrabutylammonium fluoride. The protected intermediate of formula (18) may be prepared in an analogous manner to the compounds of formula (1) using the reactions described herein and appropriately protected intermediates.

30

wherein R⁴ and/or R⁵ contains a formyl group, by oxidation with an oxidising agent, e.g. potassium permanganate, in a solvent, such as an alcohol, e.g. tert-butanol, at ambient temperature.

- 5 In a further interconversion reaction, compounds of formula (1) wherein R⁴ and/or R⁵ is substituted by an aminoalkyl group, such as dimethylaminomethyl, may be prepared by reductive amination of a corresponding compound wherein R⁴ and/or R⁵ contains a formyl group, using an amine, e.g. dimethylamine, in the presence of a reducing agent, e.g. sodium cyanoborohydride, if necessary in the presence of a catalyst, e.g. ethanolic HCl, in a solvent, such as an alcohol, e.g. methanol, at ambient temperature.

- 15 In another example of an interconversion reaction a compound of formula (1) wherein R⁴ and/or R⁵ is substituted by a formyl group, may be reduced to the corresponding alcohol, e.g. where R⁴ and/or R⁵ contains a hydroxymethyl group, using a reducing agent, e.g. sodium borohydride, in a solvent, such as an alcohol, e.g. ethanol, at a temperature from around 20°C to ambient temperature. The resulting alcohol may then be converted to the corresponding alkoxy derivative, e.g. methoxymethyl, by reaction with an alkyl halide or alkyl sulphonate using the methods and reagents described above for the alkylation of intermediates of formula (18).

- 25 In a further example of an interconversion process compounds of formula (1) wherein R⁴ and/or R⁵ contains a carboxamido (-CONHR¹¹) or an aminocarbonyl (-NHCOR¹¹) group may be prepared by reaction of the corresponding compound wherein R⁴ and/or R⁵ contains a -CO₂H or a -NH₂ group respectively by reaction with a carbamate, such as isobutyl chloroformate or ethyl chloroformate, in the presence of a base, such as an amine, e.g. triethylamine or N-methylmorpholine, in a solvent, such as dichloromethane, or a mixture of solvents, e.g. tetrahydrofuran and dimethylformamide, at a temperature from around -20°C to room temperature.

In a still further interconversion reaction, compounds of formula (1) wherein R^4 and/or R^5 is substituted by a $-NHCONHR^{11}$ group may be prepared by reacting a corresponding compound wherein R^4 and/or R^5 is substituted by an amino ($-NH_2$) group, with an isocyanate, e.g. ethyl isocyanate, in a solvent, e.g. dichloromethane, at ambient temperature.

In another example of an interconversion process, compounds of formula (1) wherein R^7 is an alkyl group, may be prepared by interconversion of a compound of formula (1) where R^7 is a hydrogen atom by reaction with a compound R^7L , where L is a leaving group, for example a halogen atom, such as chlorine, in the presence of a base, for example lithium diisopropylamide, in a solvent such as tetrahydrofuran, at low temperature, such as $0^\circ C$.

Compounds of formula (1) wherein R^3 is an OR^9 group where R^9 is an alkyl, alkoxyalkyl, formyl or alkanoyl group, may be prepared in another example of an interconversion process by reaction of a compound of formula (1) where R^3 is a $-OH$ group with a compound R^9L (where R^9 is as just defined and L is a leaving group as described above), in a solvent, such as dichloromethane or tetrahydrofuran in the presence of base, for example triethylamine or potassium tert-butoxide, at room temperature.

In a further interconversion process compounds of formula (1) wherein R^9 is a carboxamido ($-CONHR^{11}$) or a thiocarboxamido ($-CSNHR^{11}$) group, may be prepared by reaction of a compound of formula (1) wherein R^3 is a hydroxyl group with an isocyanate $R^{11}NCO$ or an isothiocyanate $R^{11}NCS$, in a solvent, for example chloroform, in the presence of a base, for example diisopropylethylamine, at ambient temperature. The isocyanate $R^{11}NCO$ and isothiocyanate $R^{11}NCS$ are known compounds or may be prepared in a conventional manner.

In a further example, a compound of formula (1) wherein R^9 is a $CONR^{11}R^{12}$ group may be prepared by reaction of a compound of formula (1) wherein R^9 is a $CONHR^{11}$ group with a reagent $R^{12}L$ (where L is a leaving group as described above) in the presence of a base, for example

In another resolution process a racemate of formula (1) may be separated using chiral High Performance Liquid Chromatography, for example as described in the Examples hereinafter.

5

Alternatively, if desired a particular enantiomer may be obtained by using an appropriate chiral intermediate in one of the processes described above. Thus, for example, the procedure and chiral intermediates described herein for the preparation of (+)-2-[2-(3-cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benz[d]oxazole (see Example 35) may be readily adapted to provide particular enantiomers of the invention.

10

The following examples illustrate the invention. The following abbreviations are used: DMF - dimethylformamide; THF - tetrahydrofuran; DME - dimethoxyethane; EtOAc - ethyl acetate; Et₂O - diethyl-ether; Et₃N - triethylamine; BuLi - butyllithium; LDA - lithium diisopropylamide; EtOH - ethanol; RT - room temperature.

15

All ¹Hnmr spectra were obtained at 300MHz unless specified otherwise.

20

INTERMEDIATE 1

3-Cyclopentyloxy-4-methoxybenzaldehyde

Cs₂CO₃ (214g, 0.66mol) was added to a mixture of 3-hydroxy-4-methoxybenzaldehyde (100g, 0.66mol) and cyclopentyl bromide (98g, 0.66mol) in anhydrous DMF (500ml). The reaction mixture was stirred at RT for 16h then treated with a further portion of cyclopentyl bromide (98g, 0.66mol) and Cs₂CO₃ (214g, 0.66mol). After a further 6h at RT, the mixture was filtered and concentrated *in vacuo*. The residue was dissolved in CH₂Cl₂ (300ml) and washed with NaOH solution (10%; 2x150ml). The organic layer was dried (MgSO₄), concentrated *in vacuo*, and distilled (150°C, 10⁻²inbar) to afford the title compound (130g) as a viscous colourless oil. δ_H (CDCl₃) 1.5-2.0 (8H, br m, CH₂)₄, 3.87 (3H, s, OMe), 4.80 (1H, br m, OCHCH₂), 6.90 (1H, d, J 8.7Hz, ArH ortho to OMe), 7.30-7.45 (2H, m, 2xArH meta to OMe), and 9.77 (1H, s, ArCHO).

30

35

INTERMEDIATE 2

a) (3-Cyclopentyloxy-4-methoxyphenyl)phenylketone

Phenyllithium (1.5M in ether-cyclohexane, 33.5ml, 50mmol) was added dropwise to a solution of Intermediate 1 (10.0g, 45.4mmol) in THF (50ml) at about -55°C. The reaction mixture was allowed to warm to RT overnight then diluted with water (100ml) and extracted with Et₂O (3x50ml). The organic extract was washed with aqueous HCl (1%, 70ml), brine (100ml), then dried (MgSO₄), and concentrated *in vacuo* to afford 1-(3-cyclopentyloxy-4-methoxyphenyl)-1-phenylmethanol (13.4g) as a white solid. m.p. 82.5-83°C; δ_H (CDCl₃) 1.5-2.0 (8H, br, m, (CH₂)₄), 2.30 (1H, br, s, OH), 3.77 (3H, s, OMe), 4.68 (1H, br, m, OCHCH₂), 5.77 (1H, s, CHOH), 6.75-6.85 (3H, m, ArH *ortho* to OMe + 2xArH *meta* to OMe), and 7.15-7.4 (5H, m, C₆H₅); m/z 298 (M⁺ 20%), 230 (50), 151 (30), 125 (100), 124 (33), 105 (38), and 92 (22).

The alcohol (prepared above) (13.4g, 44.8mmol) was dissolved in CH₂Cl₂ (150ml) and treated with MnO₂ (22g). The reaction mixture was vigorously stirred at RT for 18h then treated with a further portion of MnO₂ (20g). More MnO₂ (20g) was added after 10h and the mixture stirred for 18h then filtered through Celite® and concentrated *in vacuo*. The residue was recrystallised from EtOH to afford the title compound (11.27g; two crops) as a white crystalline solid m.p. 59-75°C; δ_H (CDCl₃) 1.5-2.1 (8H, br, m, (CH₂)₄), 3.88 (3H, s, OMe), 4.80 (1H, br m, OCHCH₂), 6.83 (1H, d, J 8.5 Hz, ArH *ortho* to OMe), and 7.25-7.8 (7H, m, 2xArH *meta* to OMe + C₆H₅); m/z 296 (M⁺ 11%), 229 (17), 228 (95), 152 (12), 151 (100), 105 (30), 77 (21), and 41 (10).

b) (3-Cyclopentyloxy-4-methoxyphenyl)(2-methoxyphenyl)ketone

From Intermediate 4 (1.35g, 5.0mmol) and 2-methoxybenzaldehyde (0.68g, 5.0mmol). Chromatography (SiO₂; EtOAc/hexane, 1:1) afforded the title compound (1.43g) as a white solid (Found: C, 73.53, H, 6.86. C₂₀H₂₂O₄ requires C, 73.60; H, 6.79%); m/z (EI) 326 (M⁺, 28%), 258 (65), 241 (82), 151 (67), 138 (32), 135 (100), and 121 (45).

INTERMEDIATE 35-Bromo-2-methoxyphenol

A solution of 5-bromo-2-methoxybenzaldehyde (100g, 0.46mol) in CHCl₃ (250ml) was cooled with an ice bath and 3-chloroperoxybenzoic acid (50-

60% purity) (146g, 0.51mol) in CHCl_3 (1000ml) added. The reaction mixture was allowed to warm slowly to room temperature and stirred for 72h. The white solid was filtered off and the filtrate concentrated *in vacuo*. The residue was dissolved in Et_2O (200ml) and washed with 1M sodium sulphite solution (2x200ml) then NaHCO_3 [half saturated] (3x200ml). The ether layer was washed with 10% aqueous NaOH (3x100ml) and the combined basic extract was acidified with concentrated hydrochloric acid and extracted with Et_2O (3x100ml). The combined organic extract was dried (MgSO_4) and florisil (10g) filtered and the solvent removed under reduced pressure to give the title compound (90g) as a pale brown solid.

INTERMEDIATE 4

4-Bromo-2-cyclopentylloxylanisole

Intermediate 3 (90g) was dissolved in DMF (300ml), and treated with Cs_2CO_3 (158g, 490mmol), and cyclopentyl bromide (73g, 52.5ml, 490mmol). After stirring overnight, further Cs_2CO_3 (35g, 107mmol) and cyclopentylbromide (12ml, 16.7g, 112mmol) were added and stirring continued for 2h. Further portions of cyclopentylbromide (10ml) and Cs_2CO_3 were then added (14g). After stirring for 1h, the DMF was evaporated *in vacuo* and the residue diluted with water (200 ml) and extracted with Et_2O (3x100ml). The combined organic extract was washed with NaOH solution (5%, 2x100ml), water (100ml), then dried (MgSO_4) and the solvent evaporated *in vacuo* to give a red oil which was distilled (140°C, 0.3mbar) to afford the title compound (101g) as a colourless oil (Found: C, 53.11; H, 5.53. $\text{C}_{12}\text{H}_{15}\text{BrO}_2$ requires C, 53.15; H, 5.58%).

INTERMEDIATE 5

a) (3-Cyclopentylloxy-4-methoxyphenyl)(4-pyridyl)ketone

$n\text{-BuLi}$ (1.45M in hexanes; 19.6ml, 28.4mmol) was added dropwise at -70°C to a solution of Intermediate 4 (7.0g, 25.8mmol) in THF (50ml). After stirring for 0.25h, a solution of 4-cyanopyridine (3.08g, 29.7mmol) in THF (15ml) was added and maintained at -70°C for 0.75h. The reaction mixture was then allowed to warm to -10°C and quenched with aqueous HCl (10%; 60ml). The mixture was stirred for 0.5h, basified with aqueous NaOH (10%, 70ml), and extracted with Et_2O (3x70ml). The extract was washed with brine (100ml), dried (MgSO_4), and concentrated *in vacuo*.

The residue was subjected to chromatography (SiO₂; EtOAc/hexane, 4:1) to afford the title compound (6.34g) as a white powder. δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.90 (3H, s, OMe), 4.82 (1H, br m, OCHCH₂), 6.84 (1H, d, \downarrow 8.4 Hz, ArH ortho to OMe) 7.29 (1H, dd, \downarrow 8.4, 2.0 Hz, ArH para to cyclopentyloxy), 7.4-7.55 (3H, m, ArH ortho to cyclopentyloxy + pyridine H₃, H₅), and 8.73 (2H, dd, \downarrow 4.4 Hz, 1.5 Hz, pyridine H₂, H₆).

b) (3-Cyclopentyloxy-4-methoxyphenyl)(4-methylphenyl)ketone

From Intermediate 4 (2.71g, 10mmol) and 4-methylbenzonitrile (1.17g, 10mmol). Chromatography (SiO₂; Et₂O/hexane, 1:1) afforded the title compound (1.80g) as a white solid; δ_H (80MHz; CDCl₃) 1.5-2.1 (8H, br m, (CH₂)₄), 2.44 (3H, s, ArMe), 3.92 (3H, s, OMe), 4.83 (1H, br m, OCH), 6.87 (1H, d, \downarrow 8.3 Hz, ArH ortho to OMe), 7.27 (2H, d, \downarrow 8.0 Hz, ArH ortho to OMe), 7.36 (1H, dd, \downarrow 8.3, 2.0Hz, ArH para to cyclopentyloxy), 7.43 (1H, d, \downarrow 2.0Hz, ArH ortho cyclopentyloxy), and 7.68 (2H, ca d, \downarrow 8.0Hz, ArH meta to Me).

c) (3-Cyclopentyloxy-4-methoxyphenyl)(4-methoxyphenyl)ketone

From Intermediate 35 (2.17g, 10.0mmol) and 4-bromoanisole (1.82g, 10.0mmol). Chromatography (SiO₂; EtOAc/hexane, 1:1) afforded the title compound (2.88g) as a white solid; δ_H (80MHz; CDCl₃) 1.45-2.05 (8H, br m, (CH₂)₄), 3.90 (3H, s, OMe), 3.94 (3H, s, OMe), 4.83 (1H, br m, OCH), 6.90 (1H, d, \downarrow 8.5Hz, ArH meta to cyclopentyloxy), 6.94 (2H, ca d, \downarrow ca 8.3Hz, ArH meta to OMe), 7.35 (1H, dd, \downarrow 8.5, 2.0Hz, ArH para to OMe), 7.40 (1H, d, \downarrow 2.0Hz, ArH ortho to cyclopentyloxy), and 7.80 (2H, ca d, \downarrow 8.3 Hz, ArH ortho to OMe). m/z (EI) 326 (M⁺, 35%), 259 (35), 258 (97), 227 (40), 151 (80), 135 (100), 77 (22), and 41 (28).

d) (3-Cyclopentyloxy-4-methoxyphenyl)(3-methoxyphenyl)ketone

From Intermediate 34 (2.17g, 10.0mmol) and 3-bromoanisole (1.82g, 10.0mmol). Chromatography (SiO₂; EtOAc/hexane, 1:1) afforded the title compound (2.87g) as a white solid (Found: C, 73.60; H, 6.73. C₂₀H₂₂O₄ requires C, 73.60; H, 6.79%); m/z (EI) 327 (M⁺ + 1.15%), 326 (M⁺ + 67), 259 (42), 258 (98), 241 (16), 227 (18), 152 (20), 151 (100), 135 (40), and 83 (17).

6.56 (1H, s, C=CH), 6.57 (1H, dd, J 8.4, 2.0 Hz, ArH para to cyclopentyloxy), 6.68 (1H, d, J 8.4 Hz, ArH ortho to OMe), 7.3-7.45 (5H, m, C₆H₅), and 8.37 (2H, s, pyridine H₂, H₆).

5 e) (E) and (Z) isomers of 3-[2-(3-Cyclopentyloxy-4-methoxy phenyl)-2-phenylethenyl]pyridazine

From the compound of Example 7b (4.0g). Purification by chromatography (SiO₂; Et₂O) afforded the title compound (2.07g) as a pale yellow solid (Found: C, 77.59; H, 6.49; N, 7.24. C₂₄H₂₄N₂O₂ requires C, 77.39; H, 6.50; N, 7.52%); δ_{H} (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.88, 3.90 (3H, s, OMe), 4.58, 4.70 (1H, br m, OCH), 6.6-7.5 (11H, m, C₆H₅+C₆H₃+C=CH + pyridazine H₄, H₅), and 8.85-8.90 (1H, m, pyridazine H₆) ('Hnmr indicates a 3:2 E/Z ratio); m/z (ESI) 396 (M^+ +1+Na, 57%), 395 (M^+ +Na, 100), 374 (66), 373 (78), and 305 (16).

15

f) (E) and (Z) isomers of 2-[2-(3-Cyclopentyloxy-4-methoxy phenyl)-2-phenylethenyl]-4-methylpyridine

From the compound of Example 7c (1.15g, 2.85mmol). Purification by chromatography (SiO₂; EtOAc) afforded the title compound (1.2g) as a pale yellow solid; δ_{H} (CDCl₃) 1.4-1.9 (8H, br m, (CH₂)₄), 2.04 (major), 2.09 (minor) (3H, pyridine Me), 3.85 (major), 3.88 (minor) (3H, s, OMe), 4.58 (minor), 4.72 (major) (1H, br m, OCH), 6.4-7.5 (11H, m, C₆H₅+C₆H₃+pyridine H₃, H₅+C=CH), 8.5-8.55 (1H, m, pyridine H₆). 'Hn.m.r indicates a 2:1 E/Z ratio.

25

g) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxy phenyl)-2-phenylethenyl]pyrimidine

From the compound of Example 7d (2.55g). Purification by chromatography (SiO₂; Et₂O) afforded the title compound (1.20g) as a pale yellow foam; δ_{H} (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.88, 3.90 (3H, s, OMe), 4.60, 4.70 (1H, br m, OCH), 6.44, 6.64 (1H, d, J 5.2Hz, pyrimidine H₅), 6.65-7.0 (3H, m, C₆H₃), 7.2-7.45 (6H, m, C₆H₅+C=CH), 8.26, 8.32 (1H, d, J 5.2Hz, pyrimidine H₆), and 9.10, 9.12 (1H, ca s, pyrimidine H₂).

35

h) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxy

phenyl)-2-(3-methoxyphenyl)ethenyl]pyridine

From the compound of Example 2b. Chromatography (SiO₂; EtOAc) afforded the title compound as a yellow oil (0.90g).

5 i) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-methoxyphenyl)ethenyl]pyridine

From the compound of Example 2c. Chromatography (SiO₂; EtOAc) afforded the title compound as a yellow oil (0.75g).

10 INTERMEDIATE 8

(E) and (Z) isomers of 4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethenyl]pyridine

A mixture of Intermediate 6 (0.48g, 1.58mmol), Cs₂CO₃ (0.56g, 1.73mmol), and cyclopentyl bromide (0.26g, 1.743mmol) in DMF (20ml) was stirred at
15 RT overnight. A further portion of Cs₂CO₃ (0.20g, 0.61mmol) and cyclopentyl bromide (0.28g, 1.86mmol) was added, the mixture stirred for 1.5h, then concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; EtOAc/CH₃OH/Et₃N, 100:1:0.4) to afford the title compound (0.42g) as a white solid. m.p. 136-138°C (cyclohexane); δ_H (CDCl₃) 1.5-
20 2.0 (8H, br m (CH₂)₄), 3.84 (3H, s, OMe), 4.65 (1H, br m OCHCH₂), 6.7-6.9 (6H, m, ArH *ortho* to OMe+2xArH *meta* to OMe+C=CH + pyridine H₃, H₅), 7.08 (2H, dd, \downarrow 4.5, 1.5 Hz, pyridine pyridine H_{3'}, H_{5'}), 8.32 (2H, dm, \downarrow 5.0 Hz pyridine H₂, H₆), and 8.55 (2H, dd, \downarrow 4.5, 1.5 Hz, pyridine H_{2'}, H_{6'}); m/z 372 (M⁺28%), 305 (37), 304 (100), 303 (95), 275 (18), and 41
25 (18)

INTERMEDIATE 9

1-(3-Cyclopentyloxy-4-methoxyphenyl)-1-phenylethene

To a cold suspension (0°C) of methyl triphenylphosphonium bromide
30 (53.6g; 0.15mol) in THF (500ml) under a nitrogen atmosphere was added n-BuLi (1.6M in hexanes; 94ml, 0.15mol) dropwise and the reaction mixture stirred at 0°C for 1h. A solution of Intermediate 2 (29.6g, 0.1mol) in THF (100ml) was added dropwise and the stirred reaction mixture allowed to warm to RT over 3h. The mixture was poured into 10% NH₄Cl
35 solution (600ml) and extracted with CH₂Cl₂ (2x500ml). The combined organic layer was dried (MgSO₄), filtered and concentrated *in vacuo*. The

residual slurry was triturated with hot hexane (500ml), the precipitated phosphine oxide filtered off and the filtrate evaporated *in vacuo* to yield the title compound (28.85g) as a yellow oil. δ_H ($CDCl_3$) 1.5-2.0 (8H, br m, $(CH_2)_4$), 3.85 (3H, s, OMe), 4.71 (1H, br m, OCH), 5.38 (2H, dd, J 10.5, 1.3Hz, C=CH₂), 6.75-6.9 (3H, m, C₆H₃), and 7.3-7.5 (5H, m, C₆H₅).

INTERMEDIATE 10

a) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxy phenyl)-2-phenylethenyl] phenol

10 A mixture of Intermediate 9 (2.94g, 10mmol), 4-bromophenol (2.16g, 12.5mmol), Et_3N (2.52g, 25mmol), tri-*o*-tolyl phosphine (0.06g, 0.2mmol) and palladium acetate (0.022g, 0.1mmol) was heated in a bomb at 140°C for 16h. Upon cooling, the reaction mixture was diluted with NH_4Cl (10%; 50ml) and CH_2Cl_2 (50ml). The organic layer was separated and the
15 aqueous layer extracted with CH_2Cl_2 (50ml). The combined organic layer was dried ($MgSO_4$), filtered and concentrated. Purification by column chromatography (SiO_2 ; hexane/ Et_2O , 1:1) yielded the title compound (1:1 mixture of isomers) (0.8g) as a yellow foam. δ_H ($CDCl_3$) 1.2-1.9 (8H, br m, $(CH_2)_4$), 3.81, 3.83 (3H, s, OMe), 4.59, 4.69 (1H, br m, OCH), 5.5, 5.63
20 (1H, br s, OH), 6.55-7.0 (8H, m, C₆H₃+C₆H₄+C=CH), and 7.15-7.35 (5H, m, C₆H₅) [N.B. 1H -n.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z (ESI) 410 (M^++1+Na , 18%), 409 (M^++Na , 100) 387 (M^++1 , 62), 319 (38), 318 (22), 301 (19), 236 (22), and 135 (20).

25 The following compounds were prepared using a similar procedure:

b) (E) and (Z) isomers of 3-[2-(3-Cyclopentyloxy-4-methoxy phenyl)-2-phenylethenyl] benzoic acid

From Intermediate 9 (2.94g, 10mmol) and 3-bromobenzoic acid (5.03g, 25mmol). Purification by column chromatography [SiO_2 ; 10%, CH_3OH/CH_2Cl_2] furnished the title compounds (2g) as a viscous yellow oil. δ_H ($CDCl_3$) 1.45-2.0 (8H, br m, $(CH_2)_4$), 3.86, 3.87 (3H, s, OMe), 4.55, 4.7 (1H, br m, OCH), 6.65-8.25 (13H, m, C₆H₅+C₆H₄+C₆H₃+C=CH), (CO_2H not observed) [N.B. 1H -n.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z
30 (ESI) 437 (M^++23 , 60%), 301 (67), 281 (100), and 259 (52).

c) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethenyl] anisole

From Intermediate 9 (1.19g, 4.04mmol) and 4-bromoanisole (0.757g, 4.05mmol). Purification by column chromatography (SiO₂; hexane/Et₂O, 4:1) furnished the title compounds (0.78g) as a yellow oil. δ_{H} (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.72, 3.73 (3H, s, OMe), 3.82, 3.86 (3H, s, OMe), 4.58, 4.67 (1H, br m, OCH), 6.6-6.9 (6H, m, C₆H₃+2xArH ortho to OMe+C=CH), 6.93, 7.00 (2H, d, J 8.5Hz, 2xArH meta to OMe) and 7.15-7.35 (5H, m, C₆H₅) [N.B. 'Hn.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z (ESI) 424 (M⁺+1+Na, 20%), 423 (M⁺+Na, 100%), 374 (12), 281 (20), 198 (12), 132 (12) and 86 (12).

d) (E) and (Z) isomers of Methyl 4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethenyl]benzoate

From Intermediate 9 (2.94g, 10mmol) and methyl 4-bromobenzoate (2.69g, 12.5mmol) to afford the title compounds (3.35g) as a yellow gum; δ_{H} (CDCl₃) 1.4-2.0 (8H, br m, (CH₂)₄), 3.86, 3.87 (6H, s, OMe+CO₂Me), 4.54, 4.67 (1H, br m, OCH), 6.6-7.4 (11H, m, C₆H₅+C₆H₃+C=CH+2xArH meta to CO₂Me), and 7.75-7.85 (2H, m, 2xArH ortho to CO₂Me) [N.B. 'Hn.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z (ESI) 429 (M⁺+1+Na, 28%), 362 (18), 361 (28), 330 (70), and 329 (68).

e) (E) and (Z) isomers of 3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethenyl]pyridine

From Intermediate 9 (1.00g, 3.4mmol) and 3-bromopyridine (1.28g, 8.1mmol). Purification by chromatography (SiO₂; Et₂O) afforded the title compound (0.50g) as a pale yellow gum; δ_{H} (CDCl₃) 1.45-2.0 (8H, br m, (CH₂)₄), 3.85 (major), 3.87 (minor) (3H, s, OMe), 4.55 (minor), 4.69 (major) (1H, br m, OCH), 6.65-7.5 (11H, m, C₆H₅+C₆H₃+pyridine H₄, H₅+C=C), and 8.2-8.45 (2H, m, pyridine H₂, H₆).

INTERMEDIATE 11

(E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethenyl] acetoxymethyl benzene

To a stirred solution of Intermediate 10a (0.2g, 0.52mmol) in CH₂Cl₂ (5ml), under a nitrogen atmosphere, was added Et₃N (0.101g, 0.14ml, 1mmol)

followed by acetyl chloride (0.0785g, 0.071ml, 1mmol). The reaction mixture was stirred at RT for 4h then poured into saturated NaHCO₃ (10ml). The organic layer was separated and the aqueous layer extracted with CH₂Cl₂. The combined organic layer was dried (MgSO₄), filtered, and the solvent removed *in vacuo* to furnish the title compounds (0.222g) as a colourless oil. δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 2.23, 2.24 (3H, s, OCOMe), 3.83, 3.86 (3H, s, OMe), 4.56, 4.67 (1H, br m, OCH), and 6.7-7.4 (13H, m, C₆H₅+C₆H₄+C₆H₃+C=CH) [N.B. ¹Hn.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z (ESI) (M^+ +Na, 100%), 319 (20), 281 (29), 191 (48), 127 (50) and 55 (54).

INTERMEDIATE 12

(E) and (Z) Isomers of Methyl 3-[2-(3-cyclopentyloxy-4-methoxyphenyl)-2-phenylethenyl]benzoate

To a cold (0°C) solution of Intermediate 10b (0.25g, 0.6mmol) in CH₃OH (20ml) was added SOCl₂ (0.357g, 0.22ml, 3mmol) dropwise and the reaction mixture was stirred at RT for 3h. The solvent was evaporated *in vacuo*, the residue dissolved in CH₂Cl₂ (20ml) and washed with saturated NaHCO₃ (20ml). The organic phase was separated and the aqueous phase extracted with CH₂Cl₂ (20ml). The combined organic layer was dried (MgSO₄), filtered and the solvent evaporated *in vacuo* to yield the title compound (0.215g) as a yellow oil. δ_H (CDCl₃) 1.4-2.0 (8H, br m, (CH₂)₄), 3.82, 3.83, 3.84, 3.85 (6H, s, OMe + CO₂Me), 4.54, 4.69 (1H, br m, OCH), and 6.65-7.85 (13H, m, C₆H₅+C₆H₄+C₆H₃+C=CH) [N.B. ¹Hn.m.r. indicates ca 1:1E/Z mixture of isomers]; m/z (ESI) 429 (M^+ +1, 25%), 361 (22), 329 (100), 159 (12), 102 (15), and 60 (75).

INTERMEDIATE 13

Ethyl (E)-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)propenoate

A mixture of Intermediate 1 (26.62g, 0.12mol), ethyl-4-pyridylacetate (19.92g, 0.12mol, 1eq) and ammonium acetate (18.63g, 0.24g, 2eq) in glacial acetic acid (200ml) was stirred at 120°C under nitrogen for 20h. The solution was cooled to RT and the acid removed *in vacuo*. The orangy/brown residue was taken up in saturated NaHCO₃ solution to pH 8.5 and the aqueous layer extracted several times with EtOAc. The

3,5-Dichloropyridine (2.04g, 13.5mmol) in THF (5ml) was added dropwise to a solution of LDA [prepared from diisopropylamine (1.9ml, 13.5mmol) and *n*-BuLi (1.6M; 8.4ml, 13.5mmol)] in THF (25ml) at -70°C. After stirring at this temperature for 5 min, iodomethane (0.85ml, 13.5 mmol) was added and the reaction mixture stirred for a further 1.5h at -70°C. Saturated NaHCO₃ (20ml) and CH₂Cl₂ (20ml) were added, the organic phase separated, dried (MgSO₄), and concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; Et₂O/hexane, 1:3) to afford the title compound (1.16g) as a pale yellow solid. δ_H (CDCl₃) 2.46 (3H, s, Me), and 8.36 (2H, s, pyridine H₂, H₆).

INTERMEDIATE 16

Ethyl 3-(3-Cyclopentyloxy-4-methoxyphenyl)-2-ethoxycarbonyl propenoate

A mixture of Intermediate 1 (109.8, 499.1mmol), diethyl malonate (79.96, 499.1mmol), piperidine (2.5ml) and CH₃CO₂H (12ml) in toluene (700ml) was heated to reflux in a Dean-Stark apparatus for 20h. Further portions of diethyl malonate (9.6g, 59.9mmol), piperidine (2.5ml), and CH₃CO₂H (12ml) were added and heating continued as before for 15h. The reaction mixture was concentrated *in vacuo* to afford the title compound (217g) as a brown oil. δ_H (CDCl₃) 1.33 (6H, t, \downarrow 7.1Hz, 2xCO₂CH₂Me), 1.5-2.05 (8H, br m, (CH₂)₄), 3.88(3H, s, OMe), 4.30 (2H, q, \downarrow 7.1Hz, CO₂CH₂Me), 4.36 (2H, q, \downarrow 7.1Hz, CO₂CH₂Me), 4.73 (1H, br m, OCH), 6.85 (1H, d, \downarrow 8.1Hz, ArH ortho to OMe), 7.0-7.1 (2H, m, 2xArH meta to OMe), and 7.63 (1H, s, HC=CCO₂Et):

INTERMEDIATE 17

Diethyl 2-[(3-Cyclopentyloxy-4-methoxyphenyl)phenylmethyl]propan-1-3-dioate

Phenylmagnesium bromide (1.0M in THF; 340ml, 340mmol, 1.29eq) was added over 1.5h to a solution of Intermediate 16 (95.6g, 264mmol) in THF (200ml) at -60°C and stirred at this temperature for a further 5h. The reaction mixture was allowed to warm to -20°C, quenched with 10% aqueous NH₄Cl (200ml), then extracted with EtOAc (3x100ml). The extract was dried (MgSO₄), concentrated *in vacuo*, the residual brown oil dissolved in EtOH and allowed to crystallise overnight to afford the title

compound (74.9g) as a white solid. m.p. 97-98°C. δ_{H} (CDCl_3) 1.01 (6H, t, J 7.1Hz, $\text{CO}_2\text{CH}_2\text{Me}$), 1.05 (3H, t, J 7.1Hz, $\text{CO}_2\text{CH}_2\text{Me}$), 1.5-2.0 (8H, br m, $(\text{CH}_2)_4$), 3.77 (3H, s, OMe), 3.9-4.1 (4H, m, $2 \times \text{CO}_2\text{CH}_2\text{Me}$), 4.26 (1H, d, J 12.1Hz, CHCHCO_2Et), 4.67 (1H, d, J 12.1Hz, CHCHCO_2Et), 4.71 (1H, br m, OCH), 6.7-6.85 (3H, m, C_6H_3), and 7.15-7.35 (5H, m, C_6H_5).

INTERMEDIATE 18

3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-phenylpropanoic acid

A mechanically stirred solution of Intermediate 17 (70.3g, 0.160mol) in NaOH solution (8M; 600ml) and dioxane (600ml) was heated to reflux for 7h. The reaction mixture was cooled, concentrated hydrochloric acid (about 400ml) added dropwise to pH4 and heating carried overnight to give a homogenous solution. The dioxane was removed *in vacuo* and the mixture partitioned between CH_2Cl_2 (500ml) and H_2O (500ml). The organic layer was separated and combined with further CH_2Cl_2 extracts (3x150ml). The extract was dried (MgSO_4) and concentrated *in vacuo* to give the title compound (55g) as a yellow solid. δ_{H} (CDCl_3) 1.5-2.0 (8H, br m, $(\text{CH}_2)_4$), 3.04 (2H, d, J 7.9Hz, $\text{CHCH}_2\text{CO}_2\text{H}$), 3.80 (3H, s, OMe), 4.45 (1H, t, J 7.9Hz, $\text{CHCH}_2\text{CO}_2\text{H}$), 4.70 (1H, br m, OCH), 6.7-6.8 (3H, m, C_6H_3), and 7.15-7.35 (5H, m, C_6H_5) (N.B. CO_2H not observed).

INTERMEDIATE 19

3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-phenylpropanoyl chloride

SOCl_2 (14.8ml, 24.1g, 3eq) was added to a solution of Intermediate 18 (23.0g, 67.5mmol) in CH_2Cl_2 (250ml) and then heated to reflux for 6h. The reaction mixture was allowed to stir at RT overnight then concentrated *in vacuo* to afford the title compound (23.7g) as a dark brown oil. δ_{H} (CDCl_3) 1.5-2.0 (8H, br m, $(\text{CH}_2)_4$), 3.62 (2H, d, J 8.0Hz, CHCH_2COCl), 3.82 (3H, s, OMe), 4.56 (1H, t, J 8.0Hz, CHCH_2COCl), 4.73 (1H, br m, OCH), 6.7-6.85 (3H, m, C_6H_3), and 7.15-7.4 (5H, m, C_6H_5).

INTERMEDIATE 20

5-(3-Cyclopentyloxy-4-methoxyphenyl)-1-[2-(1,3-dioxolanyl)]-5-phenyl-3-pentanone

A solution of the Grignard reagent (1.0M in THF, 29ml, 29.0mmol, 1.2eq) [prepared from 2-(2-bromoethyl)-1,3-dioxolane (5.25g, 29.0mmol) and

magnesium (10.8g, 33mmol)] was added dropwise at -70°C to a solution of Intermediate 19 (8.7g, 24.3mmol), in THF (200ml). The reaction mixture was stirred at -70°C for 0.5h, allowed to warm to RT over 1.75h then partitioned between Et₂O (200ml) and aqueous NaOH (1M; 100ml).

- 5 The organic layer was separated and combined with a further Et₂O extract (150ml). The extract was washed with brine (50ml), dried (MgSO₄) and concentrated *in vacuo*. Purification by column chromatography (SiO₂; 20% EtOAc/hexane) furnished the title compound (3.95g) as an off-white waxy solid. m.p. 60-62°C. δ_H (CDCl₃) 1.5-2.0 (10H, br m, (CH₂)₄ + CH₂CH₂CO), 2.46 (2H, t, \downarrow 7.5Hz, CH₂CH₂CO), 3.13 (2H, d, \downarrow 7.6Hz, CHCH₂CO), 3.7-4.0 (4H, m, O(CH₂)₂O), 3.78 (3H, s, OMe), 4.53 (1H, t, \downarrow 7.6 Hz, CHCH₂CO), 4.68 (1H, m, ArOCH), 4.80 (1H, t, \downarrow 4.3Hz, OCHO), 6.65-6.8 (3H, m, C₆H₃), and 7.1-7.3 (5H, m, C₆H₅).
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15 **INTERMEDIATE 21**

6-(3-Cyclopentyloxy-4-methoxyphenyl)-4-oxo-6-phenyl-1-hexanal

- A solution of Intermediate 20 (800mg) in a mixture of aqueous HCl (2M; 5ml) and THF (15ml) was heated at about 45°C for 1.5h. The reaction mixture was concentrated to low volume (about 5ml) and partitioned between Et₂O (50ml) and H₂O (10ml). The organic layer was separated and combined with a further Et₂O extract (30ml). The extract was washed with saturated NaHCO₃ (40ml), then brine (10ml), dried (MgSO₄) and concentrated *in vacuo*. The residual orange oil was subjected to chromatography (SiO₂; Et₂O-hexane) to afford the title compound (450mg) as a pale yellow oil. δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 2.6-2.7 (4H, m, CH₂CH₂CHO), 3.19 (2H, d, \downarrow 7.6Hz, CHCH₂CO), 3.79 (3H, s, OMe), 4.52 (1H, t, \downarrow 7.6Hz, CHCH₂CO), 4.70 (1H, br m, OCH), 6.7-6.8 (3H, m, ArH *ortho* to OMe + 2x ArH *meta* to OMe), 7.1-7.3 (5H, m, C₆H₅), and 9.71 (1H, s, CH₂CHO).
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INTERMEDIATE 22

Ethyl 5-(3-Cyclopentyloxy-4-methoxyphenyl)-3-oxo-5-phenylpentanoate

- n-BuLi (1.6M in hexanes; 29.3ml, 46.9mmol, 4.2eq) was added dropwise at -50°C to a solution of potassium ethyl malonate (2.95g, 22.3mmol, 2.1eq) in THF (60ml). The reaction mixture was allowed to warm to -10°C,
- 35

stirred for 10 min, then recooled to -65°C and treated dropwise with a precooled solution of Intermediate 19 (4.0g, 11.1mmol) in THF (20ml). The reaction mixture was stirred at -65°C for 20 min, then poured into a stirred mixture of Et_2O (100ml) and aqueous HCl (1M; 150ml). After 0.5h, the organic phase was separated and combined with further Et_2O extracts (2x75ml). The extract was dried (MgSO_4), concentrated *in vacuo*, and the residual oil subjected to chromatography (SiO_2 ; 40% Et_2O -hexane) to afford a colourless oil (3.4g) which crystallised on standing to give the title compound as a white solid. m.p. $56-58^{\circ}\text{C}$ (EtOH). δ_{H} (CDCl_3) 1.24 (3H, t, J 7 Hz, $\text{CO}_2\text{CH}_2\text{Me}$), 1.5-1.9 (8H, br m, $(\text{CH}_2)_4$), 3.27 (2H, d J 7.5 Hz, CHCH_2CO), 3.33 (2H, s, $\text{CH}_2\text{CO}_2\text{Et}$), 3.79 (3H, s, OMe), 4.14 (2H, q, J 7 Hz, $\text{CO}_2\text{CH}_2\text{Me}$), 4.52 (1H, t, J 7.5 Hz, CHCH_2CO), 4.69 (1H, m, OCH), 6.7-6.8 (3H, m, C_6H_3), and 7.1-7.35 (5H, m, C_6H_5).

15 INTERMEDIATE 23

(+)-4-[2-(3-Hydroxy-4-methoxyphenyl)-2-phenylethyl]pyridine

The compound of Example 3a (430mg) in dioxane/water (20ml:10ml) containing concentrated H_2SO_4 (10ml) was heated at 90°C for 1h. The reaction mixture was cooled, neutralised with aqueous NaHCO_3 then concentrated *in vacuo*. The residue was partitioned between EtOAc (25ml) and H_2O (15ml), and the organic phase separated. The extract was washed with brine (25ml), dried (MgSO_4) and concentrated *in vacuo*. The residue was recrystallised (EtOH) to afford the title compound (240mg) as an off-white crystalline solid m.p. $195-197^{\circ}\text{C}$ (Found: C, 78.66; H, 6.27; N, 4.59. $\text{C}_{20}\text{H}_{19}\text{NO}_2$ requires C, 78.64; H, 6.18; N, 4.42%); δ_{H} (CDCl_3) 3.30 (2H, d, J 8 Hz, CHCH_2), 3.86 (3H, s, OMe), 4.13 (1H, t, J 8 Hz, CHCH_2), 5.7 (1H, br s, OH), 6.63 (1H, dd, J 8.3 Hz, ArH para to OH), 6.71 (1H, d, J 8.3 Hz, ArH ortho to OMe), 6.80 (1H, d, J 2.2 Hz, ArH ortho to OH), 6.93 (2H, dd, J 4.5, 1.5 Hz, pyridine H₃, H₅), 7.1-7.3 (5H, m, C_6H_5), and 8.37 (2H, dd, J 4.5, 1.5 Hz, pyridine H₂, H₆).

INTERMEDIATE 24

(2S*,3S*) and (2S*,3R*) Ethyl 3-(3-Cyclopentyloxy)-4-methoxyphenyl)-3-[4-(1,3-dioxolanyl)phenyl]-2-(4-pyridyl)propanoate

2-(4-bromophenyl)-1,3-dioxolane (3.25g, 14.2mmol) in THF (10ml) was added dropwise to a stirred suspension of magnesium turnings

(358mg, 14.8mmol) in THF (5ml) at 40-45°C. The resulting green solution was allowed to cool to RT and copper (I) chloride (28mg, 0.28mmol) was added. The reaction mixture was cooled to -30°C. Intermediate 13 (4.34g, 11.8mmol) in THF (15ml) added at -25°C to -30°C, then stirred for 1h at
 5 -20°C and allowed to warm to RT over 2h. Saturated aqueous NH₄Cl (20ml) was added, THF removed *in vacuo* and the concentrate partitioned between Et₂O (50ml) and water (50ml). The organic layer was separated, washed with brine (20ml), dried (MgSO₄), and concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; Et₂O to Et₂O-EtOAc,
 10 1:1) to afford

i) (2S*, 3R*)- title compound (1.45g) as a colourless gum; δ_H (CDCl₃) 1.02 (3H, t, \downarrow 7.1Hz, CO₂CH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.70 (3H, s, OMe), 3.8-4.2 (6H, complex m, O(CH₂)O + CO₂CH₂Me), 4.35 (1H, d, \downarrow 8.0 Hz, CHCHCO₂Et), 4.55 (1H, br m, OCH), 4.60 (1H, d, \downarrow 8.0Hz, CHCHCO₂Et), 5.78 (1H, s, OCH₂O), 6.5-6.65 (3H, m, C₆H₃), 7.22 (2H, d, \downarrow 6.0Hz, pyridine H₃, H₅), 7.35-7.5 (4H, m, C₆H₄), and 8.45 (2H, d, \downarrow 6.0Hz, pyridine H₂, H₆) and

ii) (2S*, 3S*)- title compound (1.45g) as a white solid; δ_H (CDCl₃) 1.03 (3H, t, \downarrow 7.1Hz, CO₂CH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.80 (3H, s, OMe), 3.9-4.1 (6H, complex m, O(CH₂)O + CO₂CH₂Me), 4.36 (1H, d, \downarrow 8.0 Hz, CHCHCO₂Et), 4.60 (1H, d, \downarrow 8.0Hz, CHCHCO₂Et), 4.78 (1H, br m, OCH), 5.66 (1H, s, OCH₂O), 6.78 (1H, d, \downarrow 8.2Hz, ArH of C₆H₃), 6.85-6.95 (2H, m, 2xArH of C₆H₃), 7.08 (2H, d, \downarrow 6.0Hz, 2xArH of C₆H₄), 7.15-7.3 (4H, m, 2xArH of C₆H₄+pyridine H₃, H₅), and 8.42 (2H, ca.d, \downarrow 6.0Hz, pyridine H₂, H₆) .
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INTERMEDIATE 25

(S*, R*) and (S*, S*) Ethyl 3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-(4-trifluoromethylphenyl)-2-(4-pyridyl)propanoate

30 4-Bromo(trifluoromethyl)benzene (3.43ml, 24.5mmol) was added dropwise to a suspension of magnesium turnings (614mg, 25.3mmol) in Et₂O (15ml). A crystal of iodine was added and the mixture gently warmed to initiate the reaction. The dark brown solution was then added dropwise *via* a syringe to a suspension of copper bromide-dimethyl sulphide complex (2.48g,
 35 12.24mmol) in THF (30ml) at -40°C. The red-brown suspension was allowed to warm to -20°C over 0.5h then re-cooled to -40°C and treated

- with a solution of Intermediate 13 (3.00g, 8.16mmol) in THF (15ml) over 5 min. The reaction mixture was allowed to warm to RT over 2h, stirred overnight at RT, then heated at 40°C for 3h. The reaction mixture was quenched with NH₄Cl solution (20ml), concentrated *in vacuo*, and the residue partitioned between EtOAc (50ml) and water (25ml). The mixture was filtered through Celite® and the organic layer was separated, washed with aqueous NH₄OH (10%; 25ml), and brine (25ml), dried (MgSO₄), and concentrated *in vacuo* to give a red-brown oily residue which was subjected to chromatography (SiO₂; Et₂O-hexane) to afford the title compound (ca 1:1) (2.05g) as a pale yellow gum; δ_H (CDCl₃) 1.10-1.15 (3H, m, CO₂CH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.73, 3.84 (3H, s, OMe), 3.9-4.15 (2H, m, CO₂CH₂Me), 4.40 (1H, d, J 8.0 Hz, CHCHCO₂Et), 4.58, 4.80 (1H, br m, OCH), 4.6-4.75 (1H, m, CHCHCO₂Et), 6.5-6.7, 6.8-7.05 (3H, m, C₆H₃), 7.1-7.7 (6H, m, C₆H₄+pyridine H₃, H₅), and 8.48 (2H, br s, pyridine H₂, H₆).

INTERMEDIATE 26

(E) and (Z) isomers of 4-[2-(4-Aminophenyl)-2-(3-cyclopentyloxy-4-methoxyphenyl)ethenyl]pyridine

- Water (15ml) and trifluoroacetic acid (10ml) were added to Intermediate 13 (6.1g) in CH₂Cl₂ (15ml) at 0°C and the mixture allowed to warm to RT. After 6h, the reaction mixture was concentrated *in vacuo* and the residue partitioned between 10% hydrochloric acid (50ml) and EtOAc (50ml). The aqueous layer was separated, basified to pH 14 with 20% sodium hydroxide solution, and extracted with CH₂Cl₂ (3x50ml). The extract was dried (MgSO₄) and concentrated *in vacuo* to give the crude title compound (4.2g). A portion (0.40g) was subjected to chromatography (SiO₂; EtOAc) to afford the title compound (0.29g); δ_H (CDCl₃) 1.45-2.0 (8H, br m, (CH₂)₄), 3.80 (2H, br s, NH₂), 3.87, 3.90 (3H, s, OMe), 4.58, 4.70 (1H, br m, OCH), 6.6-7.2 (10H, C₆H₄+C₆H₃+pyridine H₃, H₅+C=CH), and 8.3-8.4 (2H, m, pyridine H₂, H₆); m/z (ESI) 388 (M⁺+1, 100%).

INTERMEDIATE 27

(4-Bromophenyl)(3-cyclopentyloxy-4-methoxyphenyl)ketone

- A solution of Intermediate 4 (8.00g, 29.5mmol) in THF (50ml) at -70°C was treated with *n*-BuLi (19.4ml, 31.0mmol, 1.6M solution in hexanes). The

slightly yellow solution was stirred at -70°C for 0.5h then a solution of 4-bromobenzaldehyde (5.46g, 29.5mmol) in THF (50ml) was added *via* cannula. The reaction was allowed to warm to RT over 2h then quenched with water (25ml) and extracted with Et₂O (2x50ml). The extract was dried (MgSO₄) and concentrated *in vacuo* to give a pale yellow oil which was dissolved in CH₂Cl₂ (150ml) and treated with manganese dioxide (19.24g, 0.22mol). The mixture was stirred vigorously for 20h at RT then filtered through Celite® and the residue washed with CH₂Cl₂ (5x50ml). The filtrate was concentrated *in vacuo* to give an off-white solid which was triturated with hexane to give the title compound (7.50g) as a white solid; δ_{H} (CDCl₃) 1.55-2.05 (8H, m, (CH₂)₄), 3.92 (3H, s, OMe), 4.83 (1H, m, OCH), 6.89 (1H, d, \downarrow 8.4Hz, ArH *ortho* to OMe), 7.33 (1H, dd, \downarrow 8.4, 2.0Hz, ArH *para* to OMe), 7.42 (1H, d, \downarrow 2.0Hz, ArH *ortho* to cyclopentyloxy), and 7.55-7.7 (4H, m, C₆H₄); ν_{max} (CDCl₃) 2248, 1652, 1590, and 1270 cm⁻¹; m/z (ESI) 399 (M⁺ + 2 + Na, 100%), 397 (M⁺ + Na, 90), 296 (16), and 236 (10).

INTERMEDIATE 20

a) (E) and (Z) isomers of 4-[2-(4-Bromophenyl)-2-(3-cyclopentyloxy-4-methoxyphenyl)ethenyl]pyridine

A solution of the compound of Example 1d (7.52g, 16.0mmol) and triethylamine (4.05g, 5.60ml, 40.0mmol) in CH₂Cl₂ (100ml) was cooled to 0°C and trifluoroacetic anhydride (3.70g, 2.50ml, 17.6mmol) was added dropwise. The orange-red solution was allowed to warm to RT over 20h then water (25ml) was added. The mixture was extracted with CH₂Cl₂ and the extract was dried (MgSO₄), concentrated *in vacuo* and subjected to chromatography to give the title compound (4.73g) as a white amorphous powder. (Found: C, 66.66; H, 5.27; N, 2.99. C₂₅H₂₄BrNO₂ requires C, 66.67; H, 5.37; N, 3.11%); δ_{H} (CDCl₃) 1.45-1.95 (8H, br, m, (CH₂)₄), 3.86, 3.88 (3H, s, OMe), 4.55, 4.70 (1H, br m, OCH), 6.6-6.95 (6H, m, C₆H₃, + pyridine H₃, H₅) + C=CH), 7.06, 7.21 (2H, d, \downarrow 8.4Hz, ArH of C₆H₄), 7.4-7.5 (2H, m, ArH of C₆H₄), and 8.36 (2H, ca. d, \downarrow 6.0Hz, pyridine H₂, H₆) (H n.m.r. indicates a 1:1 E/Z mixture); ν_{max} (CDCl₃) 1597, 1514, and 1251 cm⁻¹; m/z (ESI) 452 (M⁺ + 2 + Na, 100%), 450 (M⁺ + Na, 88), 384 (30) and 382 (28).

The following intermediates were prepared in a manner similar to Intermediate 28a.

b) (E) and (Z) isomers of 4-[2-(3-Cyclopentyloxy-4-methoxy-phenyl)-2-[4-(4,4-dimethyl-2-oxazoliny)]phenyl]ethenylpyridine

From Intermediate 40 (4.75g, 9.8mmol), trifluoroacetic anhydride (2.47g, 1.66ml, 11.8mmol) and triethylamine (0.99g, 1.36ml, 11.8mmol). A portion of the residue (100mg) was subjected to chromatography (SiO₂; EtOAc) to give the title compound (68mg) as a yellow foam. δ_H (CDCl₃) 1.39, 1.41 (6H, s, CMe₂), 1.5-1.95 (8H, m, (CH₂)₄), 3.85, 3.88 (3H, s, OMe), 4.11, 4.14 (2H, s, oxazoline CH₂), 4.55, 4.69 (1H, m, OCH), 6.6-6.7 (1H, m, ArH), 6.8-6.85 (3H, m, ArH), 6.91 (1H, d, J 6.2Hz, pyridine H₃, H₅), 7.23, 7.38 (2H, d, J 8.2Hz, ArH), 7.9-8.0 (2H, m, ArH), and 8.3-8.45 (2H, m, pyridine H₂, H₆); ν_{max} (CDCl₃) 1735, 1646, 1597 and 1318 cm⁻¹; m/z (ESI) 469 (M^+ , 100%).

c) (Z)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-furyl)ethenyl]pyridine

From the compound of Example 34 (1.0g, 2.64mmol) in CH₂Cl₂ (30ml), triethylamine (0.4g, 0.55ml, 3.96mmol) and trifluoroacetic anhydride (0.61g, 0.41ml, 2.91mmol). Work up [includes treatment with 10% NaOH solution (25ml)] and chromatography (SiO₂; EtOAc/hexane, 7:3) afforded the title compound (0.78g) as a pale pink solid m.p. 122-123°C; (Found: C, 76.37; H, 6.46; N, 3.85. C₂₃H₄₃NO₃ requires C, 76.43; H, 6.41; N, 3.88%); δ_H (CDCl₃) 1.45-1.9 (8H, br m, (CH₂)₄), 3.90 (3H, s, OMe), 4.65 (1H, br m, OCH), 6.07 (1H, d, J 3.3Hz, furan H₃), 6.41 (1H, dd, J 3.3, 1.8Hz, furan H₄), 6.75-6.9 (5H, m, C₆H₃ + pyridine H₃, H₅), 7.03 (1H, s, C=CH), 7.49 (1H, d, J 1.6Hz, furan H₅), and 8.33 (2H, ca. d, J 4.6Hz, pyridine H₂, H₆); m/z (ESI) 362 (M^+ + 1, 100%), 294 (45).

INTERMEDIATE 29

[4-(4,4-dimethyl-2-oxazoliny)]phenyl-3'-cyclopentyloxy-4'-methoxyphenylketone

A solution of 2-(4-bromophenyl)-4,4-dimethyloxazoline (A. J. Meyers, D. L. Temple, D. Haidukewych and E. D. Milhelich J. Org. Chem, **39**, 2787, 1974) (53.25g, 0.21mol) in THF (200ml) was added dropwise to

magnesium turnings (6.0g, 0.25g atoms). The reaction was stirred for 2h at RT, then a solution of Intermediate 1 (46.0g, 0.21mol) in THF (200ml) was added dropwise. The reaction was stirred for 16h then heated to reflux for 1 h, cooled to RT and quenched with NH₄Cl solution (200ml).

5 The layers were separated and the aqueous layer extracted with EtOAc (2x250ml). The organic layer was washed with brine (250ml), dried (MgSO₄), then concentrated *in vacuo* to give an orange oil. The crude oil was dissolved in CH₂Cl₂ (350ml) and treated with manganese dioxide (137g, 1.58mol) then stirred vigorously for 72h. The mixture was filtered
10 through Celite® and the residue washed with CH₂Cl₂ (300ml). The filtrate was concentrated *in vacuo* and the residue triturated with Et₂O to give the title compound (59.4g) as an off white amorphous powder m.p. 159°C. δ_{H} (CDCl₃) 1.41 (6H, s, CMe₂), 1.5-2.1 (8H, m, (CH₂)₄), 3.92 (3H, s, OMe), 4.15 (2H, s, oxazoline CH₂), 4.84 (1H, m, OCH), 6.89 (1H, d, J 8.4Hz, ArH ortho to OMe), 7.35 (1H, dd, J 2.0, 8.4 Hz, ArH para to OMe), 7.43 (1H, d, J 2.0 Hz, ArH ortho to cyclopentyloxy), 7.78 (2H, d, J 8.5Hz, ArH); and 8.03 (2H, d, J 8.5Hz, ArH); ν_{max} (CDCl₃) 1648 and 1271 cm⁻¹; m/z (ESI) 394 (M^+ + 1, 100%).

20 INTERMEDIATE 30

(E) and (Z) isomers of 4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzoic acid hydrochloride

A solution of intermediate 28b (4.25gm 8.8mmol) in 10% aqueous HCl (15ml) was heated to reflux for 20 min. Aqueous NaOH solution (5M;
25 20ml) and EtOH (15ml) were then added and heating continued for a further 2h. The reaction was cooled to RT and acidified to pH 1 with 10% aqueous HCl. The mixture was extracted with CHCl₃ (10x100ml), the organic extract was dried (MgSO₄) and concentrated *in vacuo* to give the title compound (2.83g) as a yellow solid; δ_{H} (d₄-MeOH) 1.45-1.8 (8H, m, (CH₂)₄), 3.86, 3.88 (3H, s, OMe), 4.66, 4.74 (1H, br m, OCH), 6.65-7.65
30 (8H, m, C=CH + C₆H₃+ pyridine H₃, H₅+ ArH meta to CO₂H), 8.05, 8.13 (2H, d, J ca. 8Hz, ArH ortho to CO₂H), and 8.46, 8.55 (2H, d, J ca. 6Hz, pyridine H₂, H₆) (N.B. CO₂H and HCl not observed); ν_{max} (Nujol) 1710, and 1633 cm⁻¹; m/z (ESI) 416 (M^+ + 1, 100%).

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INTERMEDIATE 31

Ethyl 3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-phenyl-2-(4-pyridyl)propanoate

Phenyl magnesium bromide (3M in THF) (2.3ml, 6.8mmol) was added to a slurry of copper (I) chloride (54mg, 0.55mmol) in THF (20ml) at -70°C. The yellow turbid solution was stirred at -78°C for 0.25h, then Intermediate 13 (1.00g, 2.7mmol) in THF (10ml) was added via cannula. The reaction was stirred for 2h whilst allowing to warm to RT. The mixture was quenched with saturated NH₄Cl solution (5ml) and water (20ml) then extracted with EtOAc (2x20ml). The extract was dried (MgSO₄), and concentrated *in vacuo* to give a yellow oil which was subjected to chromatography (SiO₂; EtOAc/hexane, 1:1) to give the title compound (0.29g) as a white solid m.p. 165-166°C. (Found: C, 75.48; H, 7.01; N, 3.14. C₂₀H₂₁NO₄ requires C, 75.76; H, 7.00; N, 3.14%); δ_{H} (CDCl₃) 1.03 (3H, t, J 7.1Hz, COCH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.80 (3H, s, OMe), 3.9-4.0 (2H, complex m, COCH₂CH₃), 4.35 (1H, d, J 12.3Hz, CHCl), 4.57 (1H, d, J 12.3Hz, CHCl), 4.78 (1H, m, OCH), 6.75-7.1 (8H, m, aromatic C₆H₅ + C₆H₃), 7.22 (2H, dd, J 4.6, 1.6Hz pyridine H₃, H₅), and 8.41 (2H, dd, J 4.6, 1.6Hz, pyridine H₂, H₆). ν_{max} (CDCl₃) 1734, 1602, and 1516 cm⁻¹; m/z (ESI) 468 (M⁺ + Na, 20%), 446 (M⁺ + 1, 20), 282 (22), 281 (100), and 213 (12).

INTERMEDIATE 32

(E) and (Z) Isomers of -t-Butyl N-[4-[1-(3-cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]phenyl]carbamate

A mixture of diphenyl phosphoryl azide (0.61g, 0.48ml, 2.2mmol), Intermediate 29 (1.00g, 2.2mmol), triethylamine (0.49, 0.68ml, 4.9mmol) and t-butanol (25ml) was heated to reflux for 20h. The mixture was concentrated *in vacuo* and the resulting brown oil partitioned between CH₂Cl₂ (30ml) and 5% citric acid solution (30ml). The organic layer was separated, washed with water (20ml), NaHCO₃ solution (20ml), and brine (20ml), then dried (MgSO₄) and concentrated *in vacuo* to give a red oil; which was subjected to chromatography (SiO₂; 5% MeOH/CH₂Cl₂) to give the title compound (0.60g) as a yellow foamy solid. δ_{H} (CDCl₃) 1.52, 1.54 (9H, s, CMe₃), 1.65-1.9 (8H, br m, (CH₂)₄), 3.86, 3.89 (3H, s, OMe), 4.56, 4.70 (1H, m, OCH), 6.6-7.4 (11H, m, ArH + C=CH + NCO), and 8.34 (2H, d, J 5.2Hz, pyridine H₂, H₆). (H n.m.r. indicates ca. 1:1 mixture of isomers);

ν_{\max} (CHCl₃) 3441, 1730, 1596, 1518 and 1157 cm⁻¹; m/z (ESI) 487 (M^+ +1, 75%), 472 (12), and 431 (100).

INTERMEDIATE 33

5 (S*,R*) and (S*,S*) Ethyl 3-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)-3-(thienyl)propanate

A solution of 2-bromothiophene (0.49g, 3.0mmol) in Et₂O (5ml) was added to Mg (0.08g, 3.3mmol) in Et₂O (2ml) at RT. The mixture was stirred at RT for 0.3h then heated to reflux for 0.25h before adding a solution of
10 Intermediate 13 (1.0g, 2.72mmol) in Et₂O-toluene (2:1; 15ml) dropwise over 10min at RT. The reaction mixture was stirred at RT for 18h then quenched with 10% NH₄Cl solution (60ml) and extracted with EtOAc (3x50ml). The extract was washed with brine (80ml), dried (MgSO₄), and concentrated *in vacuo*. The residual brown oil was subjected to
15 chromatography (SiO₂; Et₂O/hexane, 9:1 to Et₂O) to afford

(i) Intermediate 13 (205mg) and

(ii) title compound (132mg) after recrystallisation from Et₂O-hexane, 1:1) as a white solid m.p. 124-126°C; δ_H (CDCl₃) 0.99 (3H, t, \downarrow 7.1Hz, OCH₂Me), 1.55-2.0 (8H, br m, (CH₂)₄), 3.82 (3H, s, OMe), 3.85-4.05 (2H, m, OCH₂Me), 4.26 (1H, d, \downarrow 11.9Hz, CHCHCO₂Et), 4.81 (1H, d, \downarrow 11.9Hz, CHCHCO₂Et), 4.85 (1H, br m, OCH), 6.51 (1H, d, \downarrow 3.5Hz, thiophene H₃), 6.69 (1H, dd, \downarrow 5.1, 3.5Hz, thiophene H₄), 6.81 (1H, d, \downarrow 8.8Hz, ArH ortho to OMe), 6.95-7.0 (3H, m, thiophene H₅ + 2xArH meta to OMe), 7.30 (2H, ca d, \downarrow 4.6Hz, pyridine H₃, H₅), and 8.48 (2H, ca, d, \downarrow 4.6Hz, pyridine H₂,
20 H₆); m/z (ESI) 474 (M^+ +Na, 28%), 452 (M^+ +1, 12), 368 (25), 289 (12), 288 (38), 287 (100), and 219 (22).

INTERMEDIATE 34

30 a) (E) and (Z) Isomers of 2-Cyclopentyloxy-4-[2-(4-fluorophenyl)-1-phenylethylenyl]anisole

Dimethyl 4-fluorobenzylphosphonate (432mg, 2.0ml) was added to a mixture of sodium hydride (80mg, 2.2mmol) and Intermediate 2 (592mg, 2.0mmol) in THF (5ml) at 0°C. The reaction mixture was stirred overnight at RT then quenched with NaHCO₃ solution (5ml) and extracted with Et₂O
35 (25ml). The extract was washed with brine (10ml), dried (MgSO₄), and concentrated *in vacuo* to afford the title compound (115mg) as a

n-BuLi (1.6M solution in hexanes; 6.7ml, 10.7mmol) was added dropwise to Intermediate 4 (2.71g, 10mmol) in THF (50ml) at -70°C. After 0.5h, 3-methylbenzonitrile (1.17g, 10mmol) in THF (25ml) was added dropwise and the mixture allowed to warm to RT. The reaction mixture was poured into saturated NaHCO₃ solution (25ml) extracted with CH₂Cl₂ (2x25ml), the extract dried (Na₂SO₄), concentrated *in vacuo* and the residue dissolved in dioxane (30ml) and 10% hydrochloric acid (20ml) then heated to reflux for 3h. The cooled reaction mixture was poured into brine (25ml) and extracted with CH₂Cl₂ (2x 25ml). The extract was dried (Na₂SO₄), concentrated *in vacuo*, and the residue subjected to chromatography (SiO₂; Et₂O/hexane, 1:1) to afford the title compound (2.47g); δ_H (80MHz; CDCl₃) 1.45-2.05 (8H, br m, (CH₂)₄), 2.42 (3H, s, ArMe), 3.70 (3H, s, OMe), 4.83 (1H, br m, OCH), 6.89 (1H, d, \downarrow 8.3Hz, ArH *ortho* to OMe), 7.3-7.4 (2H, m, ArH *meta* and *para* to C=O of C₆H₃), 7.37 (1H, dd, \downarrow 8.3, 2.0Hz, ArH *para* to OMe), 7.45 (1H, d, \downarrow 2.0Hz, ArH *ortho* to cyclopentyloxy), and 7.5-7.6 (2H, m, ArH *ortho* to C=O of C₆H₄).

INTERMEDIATE 37

(-)-(E)-(4S)-3-[3-(3-Cyclopentyloxy-4-methoxyphenyl)propenoyl]-4-phenyl-2-oxazoline

A mixture of Intermediate 1 (10.0g, 45.4mmol) and malonic acid (9.45g, 90.8mmol, 2equiv) in pyridine (20ml) was stirred at 50°C until a clear solution was obtained. Piperidine (0.68ml) was added and the mixture gradually heated to 80°C over 0.5h (CO₂ evolution commences) then at ca. 80°C over 1.5h and finally heated to reflux for 0.75h. The cooled reaction mixture was poured into cold water (250ml) and acidified, with stirring and cooling, with concentrated HCl (30ml). The precipitate was collected by filtration, washed with water (6x10ml), and dried *in vacuo* to afford (E)-3-(3-cyclopentyloxy-4-methoxyphenyl)propenoic acid (11.3g) as a white solid; δ_H (CDCl₃) 1.6-2.1 (8H, br m, (CH₂)₄), 3.88 (3H, s, OMe), 4.80 (1H, br m, OCH), 6.30 (1H, d, \downarrow 15.9Hz, HC=CHCO₂H), 6.87 (1H, d, \downarrow 8.5Hz, ArH *ortho* to OMe), 7.05-7.2 (2H, m, 2xArH *meta* to OMe), and 7.72 (1H, d, \downarrow 15.9Hz, HC=CHCO₂H) (N.B. CO₂H not observed).

A mixture of the acid (8.03g, 30.6mmol) in thionyl chloride (10.9g, 6.7ml, 91.9mmol, 3.0equiv) and CH₂Cl₂ (30ml) was heated to reflux for 1h. The

reaction mixture was concentrated *in vacuo* and the residue diluted with toluene (30ml) and concentrated *in vacuo* again to afford (E)-3-(3-cyclopentyloxy-4-methoxyphenyl)propenoyl chloride (8.6g) as a dark crystalline solid; δ_H (CDCl₃) 1.5-2.1 (8H, br m, (CH₂)₄), 3.90 (3H, s, OMe), 4.81 (1H, br m, OCH), 6.47 (1H, d, J 15.4Hz, HC=CHCOCl), 6.88 (1H, d, J 8.5Hz, ArH *ortho* to OMe), 7.06 (1H, d, J 2.0Hz, ArH *ortho* to cyclopentyloxy), 7.14 (1H, dd, J 8.5, 2.0Hz, ArH *para* to cyclopentyloxy), and 7.76 (1H, d, J 15.4Hz, HC=CHCOCl).

10 n-Butyllithium (1.6M solution in hexanes; 17.4ml, 27.8mmol) was added dropwise to a stirred solution of 4-phenyloxazolidin-2-one (4.54g, 27.8mmol) in THF (140ml) at -70°C. After 0.25h at -70°C, a cold solution of the acid chloride (8.60g, 3.06mmol, 1.1equiv) in THF (40ml) was added to the resulting white slurry. The reaction mixture was stirred at -70°C for 0.5h then at 0°C for 1.5h. Saturated NaHCO₃ solution (100ml) and water (50ml) was added and the mixture extracted with EtOAc (100ml, 2x75ml). The extract was washed with saturated NaHCO₃ solution (50ml), brine (50ml), then dried (Na₂SO₄), and concentrated *in vacuo*. The residual solid (11.9g) was triturated with hot diisopropyl ether (100ml), cooled, and filtered to afford the title compound (10.9g) as white needles m.p. 107-109°C (from EtOAc/hexane, 1:1) (Found: C, 70.71; H, 6.09; N, 3.41. C₂₄H₂₅NO₅ requires C, 70.75; H, 6.19; N, 3.44%); δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.86 (3H, s, OMe), 4.29 (1H, dd, J 8.7, 3.8Hz, OCHH'), 4.71 (1H, apparent t, J 8.7Hz, OCHH'), 4.81 (1H, m, ArOCH), 5.55 (1H, dd, J 8.7, 3.8Hz, CHN), 6.84 (1H, d, J 8Hz, ArH *ortho* to OMe), 7.1-7.5 (2H, m, ArH *meta* to OMe), 7.25-7.45 (5H, m, C₆H₅), 7.70 (1H, d, J 15.6Hz, HC=CH), and 7.80 (1H, d, J 15.6Hz, HC=CH), $[\alpha]^{22}_D = -42^\circ$ (0.150g/100ml EtOH).

30 INTERMEDIATE 38

3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-phenyl-1-propanol

To a stirred solution of Intermediate 18 (9.0g, 2.65mmol) in THF (30ml) cooled to 0°C was added borane-THF complex (1.0M in THF; 3.41g, 162ml) and the reaction temperature kept below 20°C for 3h. The reaction mixture was warmed to RT, water (60ml) was added carefully, then 10% aqueous NaOH (100ml) and the stirring maintained for 0.5h. Et₂O (50ml)

was added, the organic layer separated, washed with water (1x30ml) and brine (1x30ml) then dried (Na₂SO₄). Concentration *in vacuo* afforded the title compound (9.16g) as a pale yellow oil.

5 INTERMEDIATE 39

3-(3-Cyclopentyloxy-4-methoxyphenyl)-3-phenyl-1-propanal

To Intermediate 38 (0.100g, 0.31mmol) in CH₂Cl₂ (10ml) was added 4Å molecular sieves (1 spatula) and the mixture degassed before adding pyridinium chlorochromate (0.099g, 0.47mmol). Stirring was maintained
10 for 4h at RT and the mixture cooled to 0°C before adding Et₂O (30ml). Filtration through a pad of florisil followed by concentration *in vacuo* afforded the title compound (0.98g) as a brown oil.

15 EXAMPLE 1

a) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]pyridine

n-BuLi (1.4M in hexanes; 2.7ml, 3.7mmol) was added dropwise at -70°C to a solution of 4-methylpyridine (0.35g, 3.72mmol) in THF (20ml). After
20 0.5h, a solution of Intermediate 2 (1.00g, 3.38mmol) in THF (4ml) was added over 5 min at -70°C, the mixture stirred for 1h at this temperature then allowed to warm to RT over 2h. The reaction mixture was partitioned between Et₂O (50ml) and water (50ml) and the organic layer was separated. The aqueous layer was further extracted with Et₂O (2x40ml)
25 and the combined organic extract was dried (MgSO₄) and concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; EtOAc-hexane) to afford, first, Intermediate 2 (300mg) then the title compound (738mg) as a white solid. m.p. 148-149°C (toluene-hexane) (Found : C, 77.32; H, 7.04; N, 3.50. C₂₅H₂₇O₃ requires C, 77.09; H, 6.99; N, 3.60%);
30 δ_H (CDCl₃) 1.4-1.9 (8H, br, m, (CH₂)₄), 2.3 (1H, v.br.s, OH exchanges with D₂O), 3.51 (2H, s, CH₂ pyridine), 3.78 (3H, s, OMe), 4.60 (1H, br, m, OCHCH₂), 6.65-6.9 (5H, m) and 7.15-7.4 (5H, m) (Arl ortho to OMe + 2xArH meta to OMe + C₆H₅ + pyridine H₃, H₅), and 8.22 (2H, dm, J 4.5Hz, pyridine H₂, H₆); m/z 389 (M⁺ 3%), 298 (15), 297 (69), 229 (27), 228 (37),
35 151 (43), 105 (100), 93 (52), 77 (24), and 41 (14).

The following compounds were prepared in a manner similar to the compound of Example 1a.

b) (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]pyrazine

From 2-methylpyrazine (1.0ml, 11.0mmol) and Intermediate 2 (3.24g, 11.0mmol). Trituration with Et₂O gave the title compound (0.885g) as a white solid. δ_H (CDCl₃) 1.45-1.9 (8H, br, m, (CH₂)₄), 3.73 (2H, s, CH₂ pyrazine), 3.80 (3H, s, OMe), 4.68 (1H, br, m, OCH), 6.22 (1H, br s, OCH), 6.73 (1H, d, J 8.4 Hz, ArH ortho to OMe), 6.89 (1H, dd, J 8.4, 2.0Hz, ArH para to cyclopentyloxy), 7.0 (1H, d, J 2.0Hz, ArH ortho to cyclopentyloxy), 7.1-7.5 (5H, m, C₆H₅), and 8.37 (3H, s, pyrazine H₃, H₅ H₆).

c) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-phenylethyl]-3,5-dichloropyridine

From Intermediate 15 (2.0g, 12.3mmol) and Intermediate 2 (3.65g, 12.3mmol). Purification by column chromatography (SiO₂; 0-2% MeOH/CH₂Cl₂) afforded the title compound (1.74g) as a white solid. m.p. 129-130°C. δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 2.65 (1H, br s, OCH), 3.85 (3H, s, OMe), 3.92 (1H, d, J 14Hz, CH_AH_B pyridine), 3.98 (1H, d, J 14 Hz, CH_AH_B pyridine), 4.57 (1H, br, m, OCH), 6.7-6.9 (3H, m, ArH ortho + 2x ArH meta to OMe), 7.2-7.4 (5H, m, C₆H₅), and 8.36 (2H, s, pyridine H₂, H₆).

d) 4-[2-(4-Bromophenyl)-2-(3-cyclopentyloxy-4-methoxyphenyl)-2-hydroxyethyl]pyridine

From 4-picoline (2.0ml, 1.90g, 20.4mmol) and Intermediate 26 (7.30g, 19.5mmol). Purification by column chromatography (SiO₂; gradient elution 50-75%, EtOAc/hexane) gave the title compound (7.77g) as a pale yellow foamy solid. Found: C, 63.82; H, 5.58; N, 2.96. C₂₅H₂₆BrNO₃ requires C, 64.11; H, 5.60; N, 2.99%. δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 2.7 (1H, br s, OCH), 3.46 (1H, d, J 13.1Hz, CH_AH_B pyridine), 3.54 (1H, d, J 13.1 Hz, CH_AH_B pyridine), 3.82 (3H, s, OMe), 4.64 (1H, br m, OCH), 6.75-6.9 (5H, m, C₆H₅ + pyridine H₃, H₅), 7.21 (2H, ca. d, J 8.7Hz, ArH of C₆H₄), and 8.29 (2H, ca. d, J 6.0Hz, pyridine H₂, H₆); ν_{max} . (CDCl₃) 3604, 1605.

1513, and 1256 cm^{-1} ; m/z (ESI) 470 ($M^+ + 2$, 20%), 468 (M^+ , 18), 377 (52), 375 (55), 95 (13), and 94 (100).

INTERMEDIATE 40

5 (±)-4-{2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-[4-(4,4-dimethyl-2-oxazolinyl)phenyl]-2-hydroxyethyl}pyridine

From 4-methylpyridine (1.45g, 1.52ml, 15.6mmol) and Intermediate 29 (5.82g, 14.9mmol). Trituration with Et_2O gave the title compound (6.61g) as an off-white solid. δ_{H} (CDCl_3)

10 1.37 (6H, s, CMe), 1.55-1.8 (8H, m, $(\text{CH}_2)_4$), 2.7 (1H, br s, OH), 3.56 (2H, br s, CH_2 pyridine), 3.82 (3H, s, OMe), 4.10 (2H, s, oxazoline CH_2), 4.63 (1H, m, OCH), 6.75-6.9 (5H, m, ArH), 7.37 (2H, d, J 8.6Hz, pyridine H_3 , H_5), 7.85 (2H, d, J 7.3Hz ArH *ortho* to oxazoline) and 8.29 (2H, br s, pyridine H_2 , H_6); ν_{max} (CDCl_3) 3603, 1649, 1512, and 1257 cm^{-1} ; m/z
15 (ESI) 487 ($M^+ + 1$, 100%), and 394 (61).

EXAMPLE 2

a) (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-1-hydroxy-2-(4-pyridyl)ethyl]pyridine

20 $n\text{-BuLi}$ (1.45M in hexanes; 5.1ml, 7.41mmol) was added dropwise at -70°C to a solution of 4-methylpyridine (0.69g, 7.41mmol) in THF (20ml). After 0.5h a solution of Intermediate 5 (2.0g, 6.73mmol) in THF (10ml) was added dropwise over 5 min. The reaction mixture was stirred for 0.5h at -70°C then at RT for 0.5h. Water (50ml) was added and the mixture
25 extracted with EtOAc (3x60ml). The extract was washed with brine (80ml), dried (MgSO_4), and concentrated *in vacuo*. The residue was subjected to chromatography (SiO_2 ; EtOAc to $\text{EtOAc}/\text{CH}_3\text{OH}$, 9:1) to afford the title compound (2.33g) as a white amorphous solid m.p. 99-103 $^\circ\text{C}$; δ_{H} (CDCl_3) 1.5-2.0 (9H, br, m, $(\text{CH}_2)_4$ + OH), 3.49 (2H, d, J 2.3 Hz, CH_2 COH), 4.65 (1H, br m, OCH CH_2), 6.7-6.9 (5H, m, ArH *ortho* to OMe + 2xArH *meta* to OMe + pyridine H_3 , H_5), 7.20 (2H, dd, J 4.6, 1.6 Hz, pyridine H_3 , H_5), 8.22 (2H, dd, J 4.6, 1.6 Hz, pyridine H_2 , H_6), and 8.40 (2H, dd, J 4.6, 1.6 Hz, pyridine H_2 , H_6); m/z 390 (M^+ 3%), 298 (21), 297 (14), 230 (21), 229 (91), 151 (100), 106 (22), 93 (27), 78 (12), and 41 (23).

The following compounds were prepared in a manner similar to the compound of Example 2a.

b) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-(3-methoxyphenyl)ethyl]pyridine

From Intermediate 5d (1.95g, 6.0mmol) and 4-methylpyridine (0.58ml, 6.0mmol). Chromatography (SiO₂; EtOAc) afforded the title compound as a yellow oil (2.16g). δ_H (CDCl₃) 1.45-1.9 (8H, br, m, (CH₂)₄), 2.4 (1H, br s, OH), 3.53 (2H, s, CH₂ pyridine), 3.74 (3H, s, OMe), 3.82 (3H, s, OMe), 4.64 (1H, br m, OCH), 6.7-7.0 (8H, m, C₆H₃ + pyridine H₃, H₅ + 3xArH of C₆H₄), 7.22 (1H, ca. t, J ca. 7.6Hz, ArH of C₆H₄), and 8.31 (2H, dd, J 4.4, 1.6 Hz, pyridine H₂, H₆).

c) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2(hydroxy-2-(2-methoxyphenyl)ethyl)pyridine

From Intermediate 2c (2.44g, 7.5mmol) and 4-methylpyridine (0.78ml, 8.0mmol). Chromatography (SiO₂; EtOAc) afforded the title compound (2.5g).

d) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(hydroxy-2-(4-methylphenyl)ethyl)pyridine

From Intermediate 5b (1.41g, 4.54mmol) and 4-methylpyridine (0.49ml, 5.0mmol). Chromatography (SiO₂; Et₂O) afforded the title compound as a gum (1.45g); δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 2.25 (1H, br s, OH), 2.33 (3H, s, ArMe), 3.53 (2H, s, CH₂ pyridine), 3.81 (3H, s, OMe), 4.63 (1H, br m, OCH), 6.7-6.85 (5H, m, C₆H₃ + pyridine H₃, H₅), 7.11 (2H, d, J 8.1Hz, ArH of C₆H₄), 7.24 (2H, d, J 8.1Hz, ArH of C₆H₄), and 8.32 (2H, ca. d, J 4.6 Hz, pyridine H₂, H₆).

e) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-(4-methoxyphenyl)ethyl]pyridine

From Intermediate 5c (2.46, 7.55mmol) and 4-methylpyridine (0.81ml, 8.3mmol). Chromatography (SiO₂; EtOAc) afforded the title compound as a gum (2.21g).

f) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-(3-methylphenyl)ethyl]pyridine

From Intermediate 2f (2.12g, 6.85mmol) and 4-methylpyridine (0.68ml, 7.0mmol). Chromatography (SiO₂; Et₂O) afforded the title compound (2.08g) gum; δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 2.31 (3H, s, ArMe), 3.53 (2H, s, CH₂ pyridine), 3.82 (3H, s, OMe), 4.64 (1H, br m, OCH), 6.75-6.9 (5H, m, C₆H₃ + pyridine H₃, H₅), 7.0-7.25 (4H, m, C₆H₄), and (2H, dd, J 4.5, 1.6Hz, pyridine H₂, H₆). (N.B. OH no observed).

10 EXAMPLE 3

a) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine

Intermediate 7a (3.0g, 8.09mmol) in THF (50ml) was treated with 10% Pd/C (about 500mg) and hydrogenated over 38h at RT. The reaction mixture was filtered through Celite® and the filtrate concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; EtOAc/hexane 1:1) to afford the title compound (1.87g) as a clear oil which slowly crystallised on standing (Found : C, 79.87; H, 7.26; N, 3.69. C₂₅H₂₇NO₂ requires C, 80.40; H, 7.29; N, 3.75%); δ_H (CDCl₃) 1.5-2.1 (8H, br, m, (CH₂)₄), 3.27 (2H, d, J 8.0Hz, CH₂ pyridine), 3.75 (3H, s, OMe), 4.12 (1H, t, J 8.0 Hz, PhCHCH₂), 4.61 (1H, br m, OCHCH₂), 6.5-6.7 (3H, m, ArH ortho to OMe + 2xArH meta to OMe), 6.87 (2H, dm, J 4.5Hz, pyridine H₃, H₅), 7.05-7.2 (5H, m, C₆H₅) and 8.32 (2H, dm, J 4.5Hz, pyridine H₂, H₆); m/z 373 (M⁺ 7%), 281 (38), 214 (16), 213 (100), 181 (10), and 152 (11).

25 Treatment of the free base (1.08g, 2.90mmol) in Et₂O (10ml) with ethereal HCl gave, after decantation, the title compound hydrochloride (1.182g) as a white solid. δ_H (CDCl₃) 1.5-1.7 (2H, br s, cyclopentyl H), 1.75-1.95 (6H, br s, cyclopentyl H), 3.58 (2H, d, J 7.8Hz, CH₂ pyridine), 3.80 (3H, s, OMe), 4.18 (1H, t, J 7.8 Hz, CHCH₂ pyridine), 4.67 (1H, br m, OCH), 6.67 (2H, br m, ArH), 6.76 (1H, m, ArH), 7.1-7.35 (5H, m, C₆H₅), 7.45 (2H, d, J 6.5 Hz, pyridine H₃, H₅) and 8.50 (2H, d, J 6.5 Hz, pyridine H₂, H₆).

The following compounds were prepared in a similar manner to the compound of Example 3a.

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b) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]

phenol

From Intermediate 10a (0.46g, 1.19mmol) in CH₃OH (40ml). Removal of the solvent *in vacuo* gave the title compound (0.45g) as a yellow oil; δ_H (CDCl₃) 1.4-1.9 (8H, br, m, (CH₂)₄), 3.20-3.23 (2H, m, PhCHCH₂), 3.70 (3H, s, OMe), 4.07 (1H, t, \downarrow 8.0 Hz, PhCHCH₂), 4.64 (1H, br m, OCH), 5.88 (1H, br s, OH), 6.59 (2H, ca d, \downarrow 8.6 Hz, ArH *ortho* to OH), 6.65-6.75 (3H, m, C₆H₃), 6.81 (2H, ca d, \downarrow 8.6 Hz, ArH *meta* to OH), and 7.1-7.25 (5H, m, C₆H₅); m/z (ESI) 411 (M^+ + Na, 100%), 215 (15), and 197 (50).

10 c) **(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] anisole**

From Intermediate 10c (0.47g, 1.18mmol) in CH₃OH/dioxane (1:1, 50ml). Removal of the solvent *in vacuo* gave the title compound (0.45g) as a colourless oil; δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 3.24 (2H, ca d, \downarrow ca 8.0 Hz, PhCHCH₂), 3.68 (3H, s, OMe), 3.74 (3H, s, OMe), 4.09 (1H, t, \downarrow 8.0 Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.65-6.75 (5H, m, C₆H₃ + 2xArH *ortho* to OMe), 6.89 (2H, ca d, \downarrow 8.5 Hz, 2xArH *meta* to OMe), and 7.1-7.25 (5H, m, C₆H₅); m/z (ESI) 426 (M^+ + 1+Na, 25%), 425 (M^+ + Na, 100), 279 (24), 236 (48), 211 (30), 183 (25), 151 (36), 119 (48), 87 (78), and 65 (25).

20

d) **(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] acetoxystyrene**

From Intermediate 11 (0.14g, 0.33mmol) in CH₃OH/dioxane (1:1, 40ml). Removal of the solvent *in vacuo* gave the title compound (0.13g) as a colourless oil; δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 2.24 (3H, s, COMe), 3.30 (2H, d, \downarrow 7.7 Hz, PhCHCH₂), 3.78 (3H, s, OMe), 4.11 (1H, t, \downarrow 7.7 Hz, PhCHCH₂), 4.65 (1H, br m, OCH), 6.65-6.8 (3H, m, C₆H₃), 6.88 (2H, d, \downarrow 8.5 Hz, 2xArH of C₆H₄), 6.98 (2H, d, \downarrow 8.5 Hz, 2xArH of C₆H₄), and 7.1-7.3 (5H, m, C₆H₅); m/z (ESI) 453 (M^+ + Na, 100%).

30

e) **(±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] pyrazine**

From Intermediate 7b (520mg) in THF/EtOH (12ml, 1:5). Purification by column chromatography (SiO₂; Et₂O) gave the title compound (114mg) as a white solid. m.p. 71.5-72°C. δ_H (CDCl₃) 1.4-1.9 (8H, br, m, (CH₂)₄), 3.50 (2H, d, \downarrow 8.0 Hz, CH₂CH), 3.78 (3H, s, OMe), 4.51 (1H, t, \downarrow 8.0 Hz,

35

CHCH₂), 4.66 (1H, br m, OCH), 6.7-6.75 (3H, m, ArH ortho to OMe + 2xArH meta to OMe), 7.15-7.3 (5H, m, C₆H₅), 8.17 (1H, d, J 1.5Hz, pyrazine H₂), 8.31 (1H, d, J 2.5Hz, pyrazine H₅), and 8.47 (1H, m, pyrazine H₆).

5

f) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-2-methoxypyrazine

From Intermediate 7c (2.67g, 6.6mmol) in THF/EtOH (21ml, 1:20). Purification by column chromatography (SiO₂; CH₂Cl₂) furnished the title compound (2.55g) as a colourless oil; δ_H (CDCl₃) 1.5-1.9 (8H, br m (CH₂)₄), 3.42-3.60 (2H, m, CHCH₂), 3.77 (3H, s, OMe), 3.89 (3H, s, OMe), 4.67 (1H, t, J 8.0 Hz, CHCH₂), 4.67 (1H, br m, OCH), 6.7-6.8 (3H, m, ArH ortho to OMe + 2 x ArH meta to OMe), 7.1-7.3 (5H, m, C₆H₅), 7.85 (1H, d, J 2.8Hz, pyrazine H), and 7.96 (1H, d, J 2.8Hz, pyrazine H).

15

g) (±) Methyl 4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzoate

From Intermediate 10 d (3.00g, 7.0mmol) in CH₃OH/THF (1:1, 100ml) to afford the title compound (2.87g) as a colourless gum; δ_H (CDCl₃) 1.5-1.9 (8H, br m (CH₂)₄), 3.34-3.37 (2H, m, PhCHCH₂), 3.78 (3H, s, OMe), 3.87 (3H, s, OMe), 4.15 (1H, t, J 8.0 Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.65 (1H, dd, J 7.8, 2.0Hz, ArH para to cyclopentyloxy), 6.69 (1H, d, J 2.0Hz, ArH ortho to cyclopentyloxy), 6.73 (1H, d, J 7.8Hz, ArH ortho to OMe), 7.05 (2H, ca. d, J 8.5Hz, 2xArH meta to CO₂Me), 7.15-7.3 (5H, m, C₆H₅), and 7.83 (2H, ca. d, J 8.5Hz 2xArH ortho to CO₂Me); m/z (ESI) 454 (M⁺+1+Na, 40%), 453 (M⁺+Na, 100%), 301 (12), 239 (10), and 213 (17).

25

h) (±) Methyl 3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzoate

From Intermediate 12 (140mg, 0.33mmol) in CH₃OH/THF (1:1, 20ml) to afford the title compound (137mg) as a colourless gum. δ_H (CDCl₃) 1.5-1.9 (8H, br m (CH₂)₄), 3.34-3.37 (2H, m, PhCHCH₂), 3.78 (3H, s, OMe), 3.88 (3H, s, OMe), 4.17 (1H, t, J 8.0 Hz, PhCHCH₂), 4.64 (1H, br m, OCH), 6.65-6.75 (3H, m, C₆H₃), 7.1-7.3 (7H, m, C₆H₅+2xArH meta and para to CO₂Me), and 7.75-7.85 (2H, m, 2xArH ortho to CO₂Me); m/z (ESI) 453 (M⁺+Na, 100%).

35

i) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridazine

From Intermediate 7e (1.87g). Purification by chromatography (SiO₂; Et₂O-EtOAc) afforded the title compound (0.91g) as a pale yellow oil; δ_{H} (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.6-3.7 (2H, m, CHCH₂), 3.80 (3H, s, OMe), 4.55 (1H, t, \downarrow 8.0Hz, CHCH₂), 4.65 (1H, br m, OCH), 6.7-6.8 (3H, m, C₆H₃), 6.93 (1H, dd, \downarrow 8.5, 0.8Hz, pyridazine H₄), 7.1-7.3 (6H, m, C₆H₅+, pyridazine H₅), and 8.97 (1H, dd, \downarrow 5.5, 0.8Hz, pyridazine H₆); m/z (ESI) 397 (M^+ +23, 70%), 375 (M^+ +1, 72), and 281 (100).

j) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzoic acid

From Intermediate 10b (1.75g, 4.23mmol) in CH₃OH-THF (75ml, 2:1) to afford the title compound (1.56g) as a pale orange gum; δ_{H} (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.2-3.6 (1H, v.br.s), 3.38 (2H, d, \downarrow 8.0Hz, PhCHCH₂), 3.79 (3H, s, OMe), 4.18 (1H, t, \downarrow 8.0Hz, PhCHCH₂), 4.65 (1H, br m, OCH), and 6.6-8.2 (12H, m, C₆H₅+C₆H₄+C₆H₃).

k) (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-4-methylpyridine

From Intermediate 7f (1.03g). Purification by chromatography (SiO₂; Et₂O) afforded the title compound (354mg) as a colourless oil; δ_{H} (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 2.19 (3H, s, pyridine Me), 3.43 (2H, dd, \downarrow 8.2, 1.6Hz, PhCHCH₂), 3.78 (3H, s, OMe), 4.55 (1H, t, \downarrow 8.2Hz, PhCHCH₂), 4.65 (1H, br m, OCH), 6.7-6.75 (4H, m, C₆H₃+pyridine H₃), 6.85-6.9 (1H, m, pyridine H₅), 7.1-7.3 (5H, m, C₆H₅), and 8.38 (1H, ca d, \downarrow 5.1Hz, pyridine H₆).

l) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyrimidine

From Intermediate 7g (1.10g). Purification by chromatography (SiO₂; Et₂O) afforded the title compound (299mg) as a colourless oil which slowly crystallised on standing (Found: C, 76.82; H, 6.85; N, 7.35. C₂₄H₂₆N₂O₂ requires C, 76.98; H, 7.00; N, 7.48%); δ_{H} (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.45 (2H, d, \downarrow 8.0Hz, CHCH₂), 3.78 (3H, s, OMe), 4.52 (1H, t, \downarrow

8.0Hz, CHCH₂), 4.65 (1H, br m, OCH), 6.7-6.8 (3H, m, C₆H₃), 6.89 (1H, dd, J 5.1, 1.2Hz, pyrimidine H₅), 7.15-7.4 (5H, m, C₆H₅), 8.44 (1H, d, J 5.1Hz, pyrimidine H₆), and 9.11 (1H, d, J 1.2Hz, pyrimidine H₂).

5 m) 2-Cyclopentyloxy-4-[2-(4-fluorophenyl)-1-phenylethyl]anisole

From Intermediate 34a (65mg). Filtration through Celite® and concentration *in vacuo* afforded a colourless gum (62mg) which slowly solidified to give the title compound as a white solid; δ_H (CDCl₃) 1.5-1.95 (8H, br m, (CH₂)₄), 3.27 (2H, d, J 8.2Hz, CHCH₂ pyridine), 3.78 (3H, s, OMe), 4.08 (1H, t, J 8.2Hz, CHCH₂ pyridine), 4.64 (1H, br m, OCH), 6.6-6.75 (3H, m, C₆H₃), 6.8-7.0 (4H, m, C₆H₄), and 7.1-7.3 (5H, m, C₆H₅).

15 n) (±)-4-[2-(4-Chlorophenyl)-1-phenylethyl]-2-cyclopentyloxyanisole

From Intermediate 34b (200mg, 0.49mmol). Trituration with hexane afforded the title compound (45mg) as a white solid m.p. 63°C. δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.2-3.3 (2H, m, PhCHCH₂), 3.78 (3H, s, OMe), 4.08 (1H, t, J 7.8Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.6-6.7 (2H, m, ArH meta to OMe), 6.73 (1H, d, J 8.2Hz, ArH ortho to OMe), 6.90 (2H, d, J 8.3Hz, 2xArH of C₆H₄), and 7.0-7.3 (7H, m, C₆H₅ + 2xArH of C₆H₄) (N.B.) ('Hn.m.r. indicates the presence of ca 10% of the des-chloro compound); m/z 431 (M⁺+2 + Na, 40%), 430 (M⁺ + 1 + Na, 38), 429 (M⁺+Na, 100), 396 (22), 395 (92), 301 (15), 236 (15), 213 (15), and 60 (27).

25 o) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-pyridine

From Intermediate 10e (390mg, 1.05mmol). Chromatography (SiO₂; Et₂O) afforded the title compound (200mg) as a colourless oil; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.31 (2H, d, J 8.0Hz, CHCH₂ pyridine), 3.78 (3H, s, OMe), 4.10 (1H, t, J 8.0Hz, CHCH₂ pyridine), 4.65 (1H, br m, OCH), 6.6-6.8 (3H, m, C₆H₃), 7.0-7.5 (7H, m, C₆H₅ + pyridine H₄, H₅), 9.30 (1H, d, J 1.0Hz, pyridine H₂), and 9.48 (1H, dd, J 3.0, 2.0Hz, pyridine H₆), m/z (ESI) 374 (M⁺+1, 100%), 321 (20), and 306 (80).

35 EXAMPLE 4

(±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]

pyridine

A solution of Intermediate 8 (0.20g, 0.54mmol) in EtOH (10ml) containing Et₃N (0.5ml) was hydrogenated over 10% Pd/C (54mg) for 18h. The reaction mixture was filtered through Celite® and concentrated *in vacuo*.

- 5 The residue was subjected to chromatography (SiO₂; EtOAc/CH₃OH, 19:1) to afford the title compound (170mg) as a colourless oil. δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 3.27 (2H, d, J 8.0 Hz, CH₂ pyridine), 3.77 (3H, s, OMe), 4.10 (1H, t, J 8.0 Hz, CH₂CH pyridine), 4.62, (1H, br m, OCHCH₂), 6.5-6.8 (3H, m, ArH *ortho* to OMe+ 2xArH *meta* to OMe), 6.88
10 (2H, dd, J 4.5, 1.5 Hz, pyridine H₃, H₅), 7.06 (2H, dd, J 4.5, 1.5 Hz, pyridine H₃, H₅), 8.35 (2H, dd, J 4.5, 1.5 Hz, pyridine H₂, H₆), and 8.43 (2H, dd, J 4.5, 1.5 Hz, pyridine H₂, H₆); m/z 374 (M⁺ 17%), 306 (32), 282 (12), 215 (16), 214 (100), 154 (11), 129 (14), 93 (12), 57 (15), and 41 (18).

- 15 Treatment of the title compound with ethereal solution furnished the title compound dihydrochloride. m.p. 230-233°C (dec).

EXAMPLE 5

- a) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-fluorophenylethyl) pyridine hydrochloride
20

- To Intermediate 14 (2.19g, 4.72mmol) in EtOH(50ml) was added NaOH (1.0g, 25mmol) in water (20ml). The reaction mixture was heated to reflux until complete hydrolysis (about 1h) and the pH adjusted to pH 6 with concentrated hydrochloric acid (about 2ml). The reaction mixture was
25 then heated to reflux until complete decarboxylation occurred (about 7h). Upon cooling, the yellow solution was half-concentrated and partitioned between 0.5N NaOH (100ml) and Et₂O (100ml). The organic layer was washed with brine, dried (MgSO₄) and evaporated. The residual yellow tinged gum (1.81g) was taken up in Et₂O (50ml) and 2.5M hydrochloric acid in EtOH (about 2ml) was added to pH2. The solvent was evaporated and the yellow foam obtained redissolved in EtOH (20ml). Et₂O was
30 added until the solution became slightly cloudy and the mixture cooled to 0°C to give an off-white solid. The mother liquor was decanted off, the solid washed with Et₂O and dried *in vacuo* to give the title compound
35 (1.85g) as an off-white solid. m.p. 147-150°C. δ_H (CD₃OD) 1.50-1.90 (8H, m, (CH₂)₄), 3.70 (2H, d, CH₂Ar), 3.75 (3H, s, OCH₃), 4.45 (1H, t, CHAr),

4.75, (1H, m, OCH₂CH₂), 6.80 (3H, m, Ar), 7.05 (2H, m, Ar), 7.35 (2H, m, Ar), 7.90 (2H, d, Ar), 8.65 (2H, d, Ar); *m/z* (ESI) 393 (*M*⁺+2, 12%), 392 (*M*⁺+1, 38), 300 (29), and 299 (100).

- 5 The following compound was prepared in a similar manner to the compound of Example 5a.

b) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-trifluoromethylphenyl)ethyl]pyridine hydrochloride

- 10 From intermediate 25 (2.05g, 3.99 mmol) and NaOH (0.80g, 20mmol) to afford the free base (1.70g) as a pale yellow gum; δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.36 (2H, d, *J* 7.6, 0.8Hz, CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.23 (1H, t, *J* 7.6Hz, CHCH₂ pyridine), 4.67 (1H, br m, OCH), 6.65 (1H, d, *J* 2.0Hz, ArH *ortho* to cyclopentyloxy), 6.70 (1H, dd, *J* 7.8, 2.0Hz, ArH *para* to OMe), 6.79 (1H, d, *J* 7.8Hz, ArH *ortho* to OMe), 6.94 (2H, d, *J* 5.2Hz, pyridine H₃, H₅), 7.30 (2H, d, *J* 8.3Hz, 2xArH *meta* to CF₃), 7.55 (2H, d, *J* 8.3Hz, 2xArH *ortho* to CF₃), and 8.42 (2H, d, *J* 5.2Hz, pyridine H₂, H₆); *m/z* (ESI) 443 (*M*⁺+2, 24%) 442 (*M*⁺+1, 87), 350 (22), 349 (100), 281 (40), and 250 (30).

20

- Treatment of the free base (1.65g) in Et₂O(50ml) with ethanolic HCl (2.5*M*), concentration *in vacuo* and recrystallisation (EtOH-Et₂O) afforded the title compound (1.66g) as an off-white solid m.p. 149-152°C; δ_H (d₄-MeOH) 1.55-1.95 (8H, br m, (CH₂)₄), 3.77 (3H, s, OMe), 3.78 (2H, d, *J* 7.8Hz, CHCH₂ pyridine), 4.60 (1H, t, *J* 7.8Hz, CHCH₂ pyridine), 4.75 (1H, br m, OCH), 6.8-6.9 (3H, m, C₆H₃), 7.5-7.65 (4H, m, C₆H₄), 7.91 (2H, d, *J* 5.2Hz pyridine H₃, H₅), and 8.68 (2H, d, *J* 5.2Hz, pyridine H₂, H₆). (N.B. HCl not observed).

25

- 30 c) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-thienylethyl]pyridine hydrochloride

- From Intermediate 33 (566mg, 1.25mmol). Chromatography (SiO₂; EtOAc/hexane, 4:1) afforded the title compound free base (350mg) as a colourless oil; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.25 (1H, dd, *J* 13.5, *ca.* 8Hz, CHCH_AH_B), 3.41 (1H, dd, *J* 13.5, *ca.* 7Hz, CHCH_AH_B), 3.80 (3H, s, OMe), 4.36 (1H, t, *J* *ca.* 8, *ca.* 7 Hz, CHCH_AH_B), 4.65 (1H, br m, OCH),

35

6.65-6.85 (4H, m, C₆H₃ + thiophene H₃), 6.90 (1H, dd, J 5.1, 3.5 Hz, thiophene H₄), 6.94 (2H, dd, J 4.4, 1.6 Hz, pyridine H₃, H₅), 7.16, (1H, dd, J 5.1, 1.2 Hz, thiophene H₅), and 8.40 (2H, dd, J 4.4, 1.6 Hz, pyridine H₂, H₆); m/z (ESI) 381 (M⁺+2, 13%), 381 (M⁺+1, 65), 288 (2), and 287 (100).

Treatment of the free base (270mg) in Et₂O (15ml) with ethanolic HCl (2.5M), afforded the title compound (226 mg) as a pale yellow solid. δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.51 (1H, dd, J 13.5, 8.6 Hz, CHCH_AH_B), 3.64 (1H, dd, J 13.5, 7.2 Hz, CHCH_AH_B), 3.81 (3H, s, OMe), 4.41 (1H, ca. t, J ca. 7.8 Hz, CHCH_AH_B), 4.72 (1H, br m, OCH), 6.64 (1H, dd, J 8.2, 2.0 Hz, ArH para to OMe), 6.7-6.8 (3H, m, 2x ArH of C₆H₃ + thiophene H₃), 6.91 (1H, dd, J 5.1, 3.5 Hz, thiophene H₄), 7.19 (1H, dd, J 5.1, 1.0 Hz, thiophene H₅), 7.49 (2H, d, J 6.3 Hz, pyridine H₃, H₅), and 8.55 (2H, d, J 6.3 Hz, pyridine H₂, H₆).

EXAMPLE 6

(+)-4-[2-(3-Cyclopentyloxy-4-methoxy)-2-phenylethyl]pyridine-N-oxide

A solution of a compound of Example 16 (i) (264mg) in peracetic acid (0.5ml) and CH₂Cl₂ (50ml) was stirred at RT for 3h. Additional peracetic acid (0.5ml) was added and the mixture stirred overnight then treated with saturated aqueous sodium sulphite for 5 min. The organic phase was separated and combined with further CH₂Cl₂ extracts (2 x 30ml). The extract was washed with aqueous HCl (10%; 30ml), aqueous NaHCO₃ (2 x 30ml), brine (30ml), then dried (MgSO₄), and concentrated *in vacuo*. Purification by column chromatography (SiO₂; 1-5% CH₃OH/CH₂Cl₂) gave a colourless oil which was triturated with Et₂O-hexane to afford the title compound (260mg) as a white solid. m.p. 114-116°C. δ_H (CDCl₃) 1.5-1.9 (8H, br, m, (CH₂)₄), 3.29 (2H, d, J 8 Hz, CHCH₂), 3.80 (3H, s, OMe), 4.06 (1H, t, J 8 Hz, CHCH₂), 4.67, (1H, br m, OCH), 6.65-6.8 (3H, m, ArH ortho to OMe + 2x ArH meta to OMe), 6.84 (2H, d, J 7 Hz, pyridine H₃, H₅), 7.1-7.35 (5H, m, C₆H₅), and 8.00 (2H, d, J 7 Hz, pyridine H₂, H₆). (Optical rotation at 0.153g/100ml of EtOH [α]_D²² = +43°).

EXAMPLE 7

a) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]-2-methoxypyrazine

n-BuLi (1.6M in hexanes; 6ml, 12mmol) was added dropwise at 4°C to a solution of N, N-diisopropylamine (1.85ml, 13mmol) in THF (40ml). After 0.5h, 2-methoxy-3-methylpyrazine (1.28ml, 11mmol) was added dropwise at -70°C and the mixture stirred for 2h at this temperature. A solution of Intermediate 2 (3.26g, 11mmol) in THF (20ml) was added over 10 min at -70°C and the mixture stirred for a further 1h and then allowed to warm to RT. The reaction mixture was partitioned between CH₂Cl₂ (75ml) and saturated NaHCO₃ (100ml). The organic layer was separated, combined with further CH₂Cl₂ extracts (2x75ml), dried (MgSO₄) and concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; CH₂Cl₂) to afford the title compound (2.94g) as a white foam. δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.63 (1H, d, J 14 Hz, CHH pyrazine), 3.77 (1H, d, J 14Hz, CHH pyrazine), 3.79 (3H, s, OMe ortho to cyclopentyloxy), 3.97 (3H, s, pyrazine OMe), 4.67 (1H, br m, OCH), 6.72 (1H, dd, J 8.4Hz, ArH ortho to OMe), 6.77 (1H, s, OH), 6.91 (1H, dd, J 8.4Hz, 2.0Hz, ArH para to cyclopentyloxy), 7.00 (1H, d, J 2.0Hz, ArH ortho to cyclopentyloxy), 7.1-7.5 (5H, m, C₆H₅), and 7.85-7.95 (2H, m, pyrazine H₅, H₆).

The following compounds were prepared in a manner similar to the compound of Example 7a.

b) (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]pyridazine

From 3-methylpyridazine (1.0ml) and Intermediate 2 (3.98g). Purification by chromatography (SiO₂; EtOH-CH₂Cl₂) afforded the title compound (4.02g) as an off-white solid.

c) (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]-4-methylpyridine

From 2,4-dimethylpyridine (1.7ml, 14.5mmol) and Intermediate 2 (4.30g, 14.5mmol). Purification by chromatography (SiO₂; CH₂Cl₂) afforded the title compound (1.23g) as a colourless oil (Found: C, 77.07; H, 7.10; N, 3.25. C₂₆H₂₉NO₃ requires C, 77.39; H, 7.24; N, 3.47%); δ_H (CDCl₃) 1.4-1.9 (8H, br m, (CH₂)₄), 2.25 (3H, s, pyridine Me), 3.60 (2H, s, CH₂

pyridine), 3.77 (3H, s, OMe), 4.68 (1H, br m, OCH), 6.72 (1H, d, \downarrow 8.5Hz, ArH ortho to OMe), 6.8-6.95 (3H, m, ArH para to cyclopentyloxy + pyridine H₃, H₅), 7.02 (1H, d, \downarrow 2.2Hz, ArH ortho to cyclopentyloxy), 7.1-7.3 (3H, m, meta and para ArH of C₆H₅), 7.46 (2H, ca d, \downarrow 8.5Hz, ortho ArH of C₆H₅), and 8.23 (1H, ca d, \downarrow 6 Hz, pyridine H₆); m/z (ESI) 404 (M⁺+1, 72%), 387 (13), and 386 (100).

d) (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-hydroxy-2-phenylethyl]pyrimidine

10 From 4-methylpyrimidine (1.0ml) and Intermediate 2 (3.98g). Purification by chromatography (SiO₂;CH₂Cl₂) afforded the title compound (2.56g) as a white solid; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.66 (2H, s, CH₂ pyrimidine), 3.77 (3H, s, OMe), 4.65 (1H, br m, OCH), 6.58 (1H, s, OH), 6.72 (1H, d, \downarrow 8.4Hz, ArH ortho to OMe), 6.85 (1H, dd, \downarrow 8.4, 2.2Hz, ArH para to cyclopentyloxy), 6.98 (1H, d, \downarrow 2.2Hz, ArH ortho to cyclopentyloxy), 7.07 (1H, d, \downarrow 5.2Hz, pyrimidine H₅), 7.15-7.45 (5H, m, C₆H₅), 8.53 (1H, d, \downarrow 5.2Hz, pyrimidine H₆), and 8.99 (1H, s, pyrimidine H₂).

EXAMPLE 8

20 (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-1-methylpyrrole

CH₃NH₂ (generated from a concentrated aqueous solution of CH₃NH₂.HCl and KOH) was bubbled into a stirred solution of Intermediate 21 (400mg) in toluene (20ml) containing a catalytic amount of CH₃NH₂.HCl at RT for 0.5h. Et₃N (2 drops) was added and the reaction mixture concentrated in vacuo. The residue was subjected to chromatography (SiO₂; 20% Et₂O/hexane) to afford the title compound (290mg) as a colourless oil. δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.23 (2H, d, \downarrow 7.5Hz, CHCH₂CO), 3.28 (3H, s, NMe), 3.79 (3H, s, OMe), 4.19 (1H, t, \downarrow 7.5Hz, CHCH₂CO), 4.66 (1H, m, OCH), 5.74 (1H, m, pyrrole H), 5.97 (1H, app. t, \downarrow 3.2Hz, pyrrole H), 6.44 (1H, app. t, \downarrow 2.2Hz, pyrrole H), 6.67 (1H, d, \downarrow 1.8Hz, ArH ortho to cyclopentyloxy), 6.70 (1H, dd, \downarrow 8.1Hz, ArH para to cyclopentyloxy), 6.76 (1H, d, \downarrow 8 Hz, ArH ortho to OMe), and 7.13-7.30 (5H, m, C₆H₅).

35 EXAMPLE 9

(±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-5-hydroxy-[1H]-pyrazole

A solution of Intermediate 22 (503mg, 1.2mmol) and hydrazine monohydrate (73mg, 1.5mmol) in EtOH (10ml) was heated to reflux for 1.5h then cooled in an ice-bath. The crystalline product was filtered off, washed with cold EtOH and dried *in vacuo* to afford the title compound (3.5mg) as a white solid. m.p. 189-190°C. δ_H (CDCl₃) (indicates mixture of enol:keto forms; 2:1) 1.5-1.9 (8H, br m, (CH₂)₄), 2.85 (2/3H, s, CH₂CO; keto), 3.13 (4/3H, d, \downarrow 8Hz, PhCHCH₂; Keto), 3.25 (2/3H, d, \downarrow 8Hz, PhCHCH₂; enol), 3.80 (3H, s, OMe), 4.12 (2/3H, t, \downarrow 8Hz, PhCHCH₂; enol), 4.19 (1/3H, t, \downarrow 8Hz, PhCHCH₂; keto), 4.68 (1H, m, OCH), 5.35 (2/3H, s, HC=COH; enol), 6.65-6.8 (3H, m, C₆H₃), and 7.15-7.35 (5H, m, C₆H₅). (N.B. 2/3H for HC=COH; enol and NH for keto and enol forms not observed).

EXAMPLE 10

(±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]thiophene

A mixture of Intermediate 19 (4.75mg) and Lawesson's Reagent (2,4-bis (4-methoxyphenyl)-1,3-dithia-2,4-diphosphetane-2,4-disulphide)(760mg) in toluene (10ml) was stirred at 85°C for 1.5h. The reaction mixture was cooled and filtered. The filtrate was concentrated *in vacuo* and the residual oil subjected to chromatography (SiO₂; 10% Et₂O/hexane) to afford the title compound (380mg) as a colourless oil (Found: C, 76.12; H, 6.88. C₂₄H₂₆O₂S requires C, 76.15; H, 6.92%); δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.56 (2H, d, \downarrow 7.6Hz, PhCHCH₂), 3.81 (3H, s, OMe), 4.21 (1H, t, \downarrow 7.6Hz, PhCHCH₂), 4.71 (1H, br m, OCH), 6.63 (1H, dd, \downarrow 3.4, 0.9Hz, thiophene H₃), 6.75-6.80 (3H, m, C₆H₃), 6.82 (1H, dd, \downarrow 5.1, 3.4Hz, thiophene H₄), 7.05 (1H, dd, \downarrow 5.1, 1.2Hz, thiophene H₅), and 7.15-7.35 (5H, m, C₆H₅).

EXAMPLE 11

(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] benzoic acid monohydrate

Aqueous NaOH (10%; 50ml) was added to the compound of Example 3g (2.7g, 6.28mmol) in CH₃OH (50ml) and the mixture heated to reflux for 3h. CH₃OH was removed *in vacuo*, the remaining aqueous phase adjusted to

pH7 with concentrated hydrochloric acid then extracted with CH₂Cl₂ (2x100ml). The extract was dried (Na₂SO₄) and concentrated *in vacuo* to afford the title compound (2.41g) as a white solid. m.p. 187-188.5°C. (Found: C, 74.44; H, 6.40. C₂₇H₂₈O₄ · H₂O requires C, 74.62; H, 6.96%).
 5 δ_H (CDCl₃) 1.2-2.0 (~10H, br m, (CH₂)₄+H₂O), 3.3-3.45 (2H, m, PhCHCH₂), 3.78 (3H, s, OMe), 4.16 (1H, t, J 8.0Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.62 (1H, d, J 2.0Hz, ArH *ortho* to cyclopentyloxy), 6.69 (1H, dd, J 8.0, 2.0Hz, ArH *para* to cyclopentyloxy), 6.74 (1H, d, J 8.0Hz, ArH *ortho* to OMe), 7.09 (2H, d, J 8.2Hz, 2 x ArH *meta* to CO₂H), 7.15-7.3 (5H, m, C₆H₅), and 7.90 (2H, d, J 8.2Hz, 2xArH *ortho* to CO₂H); *m/z* (ESI) 439 (M⁺+Na, 100%), 415 (20), 331 (25), 302 (28), 301 (35), and 213 (70).

EXAMPLE 12

(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]

15 benzamide

To the compound of Example 11 (210mg, 0.52mmol) in CH₂Cl₂ (10ml) was added Et₃N (58mg, 0.58mmol) followed by isobutyl chloroformate (79mg, 0.58mmol) at RT and stirred for 0.5h. Ammonia was bubbled into the mixture for 10min and stirring continued for a further 0.5h. The
 20 reaction mixture was poured into aqueous NaHCO₃ (20ml) and extracted with CH₂Cl₂ (2x20ml). The extract was dried (MgSO₄), concentrated *in vacuo* and the residue subjected to chromatography (SiO₂; Et₂O) to afford the title compound (150mg) as an off-white solid m.p. 73-75°C. δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.35-3.79 (2H, m, PhCHCH₂), 3.79 (3H, s, OMe), 4.14 (1H, t, J 8.0Hz, PhCHCH₂), 4.65 (1H, br m, OCH), 5.5-6.0 (2H, v.br. s, CONH₂), 6.65 (1H, d, J 2.0Hz, ArH *ortho* to cyclopentyloxy), 6.68 (1H, dd, J 8.1, 2.0Hz, ArH *para* to cyclopentyloxy), 6.74 (1H, d, J 8.1Hz ArH *ortho* to OMe), 7.07 (2H, d, J 8.3Hz, 2xArH *meta* to CONH₂), 7.15-7.3 (5H, m, C₆H₅), and 7.62 (2H, d, J 8.3Hz, 2xArH *ortho* to CONH₂); *m/z* (ESI) 439 (M⁺+1+Na, 25%), and 438 (M⁺+Na, 100%).
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EXAMPLE 13

a) (±)-tert-Butyl N-[4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] phenyl]carbamate

35 To the compound of Example 11 (1.5g, 3.6mmol) in 2-methylpropan-2-ol (50ml) was added Et₃N (360mg, 3.6mmol) followed by diphenylphosphoryl

azide (990mg, 3.6mmol) and the mixture heated to reflux for 3h. The cooled reaction mixture was poured into aqueous NaHCO₃ (100ml) and extracted with CH₂Cl₂ (2x100ml). The extract was dried (MgSO₄), concentrated *in vacuo* and the residue subjected to chromatography (SiO₂; hexane/Et₂O, 2:1) to afford the title compound (510mg) as a white solid m.p. 123-125°C; δ_H (CDCl₃) 1.49, 1.50 (9H, s, CMe₃), 1.5-1.95 (8H, br m, (CH₂)₄+H₂O), 3.25 (2H, d, J 7.5Hz, PhCHCH₂), 3.782, 3.790 (3H, s, OMe), 4.10 (1H, t, J 7.5Hz, PhCHCH₂), 4.65 (1H, br m, OCH), 6.33 (1H, br s, NH), 6.65-6.75 (3H, m, C₆H₃), 6.91 (2H, -d, J 8.4Hz, 2xArH *ortho* to NHCO₂CMe₃), and 7.1-7.45 (7H, m, C₆H₅+2xArH *meta* to NHCO₂CMe₃). [N.B. CONH conformers observed by ¹Hn.m.r.].

The following compound was prepared in a manner similar to the compound of Example 13a.

b) (±)-tert-Butyl N-{3-[2-(3-cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]phenyl}carbamate

From a compound of Example 3 j (1.44g, 3.46mmol), in 2-methylpropan-2-ol (50ml), Et₃N (0.35g, 3.46mmol) and diphenylphosphoryl azide (0.95g, 3.46mmol). Purification by chromatography (SiO₂; hexane-EtOAc, 4:1) to afford the title compound (0.64g) as a colourless gum; δ_H (CDCl₃) 1.4-1.9 (8H, br m, (CH₂)₄), 1.50 (9H, s, CMe₃), 3.28 (2H, ca. d, J 8.0Hz, PhCHCH₂), 3.77 (3H, s, OMe), 4.16 (1H, t, J 8.0Hz, PhCHCH₂), 4.65 (1H, br m OCH), 6.39 (1H, br s, NH), and 6.6-7.4 (12H, m, C₆H₅+C₆H₄+C₆H₃).

EXAMPLE 14

(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]phenyl-N-ethylcarbamate

Ethyl isocyanate (71mg, 1.0mmol) and a catalytic amount of Et₃N (10μl) was added to a compound of Example 3b (300mg, 0.8mmol) in toluene (20ml) and the mixture heated at 60°C for 4h. The reaction mixture was poured into aqueous NaHCO₃ (50ml) and extracted with CH₂Cl₂ (2x50ml). The extract was dried (MgSO₄), concentrated *in vacuo*, and the residue subjected to chromatography (SiO₂; Et₂O/hexane, 1:1) to afford the title compound (140mg) as a colourless gum; δ_H (CDCl₃) 1.18 (3H, t, J 7.2Hz, NHCH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.2-3.35 (2H, m, NHCH₂Me), 3.29

(2H, d, J 7.8Hz, PhCHCH_2), 3.78 (3H, s, OMe), 4.11 (1H, t, J 7.8Hz, PhCHCH_2), 4.65 (1H, br m, OH), 4.98 (1H, br s, NH), and 6.6-7.3 (12H, m, $\text{C}_6\text{H}_5 + \text{C}_6\text{H}_4 + \text{C}_6\text{H}_3$); m/z (ESI) 483 ($\text{M}^+ + 1 + \text{Na}$, 38%), 482 (100), and 186 (23).

5

EXAMPLE 15

(i) (+)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]pyridine

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(ii) (-)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]pyridine

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A 60mg ml^{-1} solution of the compound of Example 4 in EtOH was made up and prefiltered through a 45 μ filter. The sample solution was injected onto a preparative chiracel OJ preparative column (mobile phase: 90:10, hexane/EtOH; flow rate 6 $\text{ml} \cdot \text{min}^{-1}$) in 0.5ml aliquots (a column loading of 30 mg). The two enantiomeric peaks were collected with a typical retention time of 50 to 63 min for the first peak and 70 to 105 min for the second peak.

EXAMPLE 16

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(i) (+)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine

(ii) (-)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine

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The compound of Example 3a (500mg) was made up to a 100mg ml^{-1} solution in EtOH, filtered through a 45 μ filter. The sample solution was injected onto a preparative chiracel OJ preparative column (mobile phase: 80:20, hexane/EtOH; flow rate 6 $\text{ml} \cdot \text{min}^{-1}$) in 0.9ml aliquots. The two enantiomeric peaks were collected with a typical retention time of 22 to 32 min for the first peak corresponding to title enantiomer (i) (optical rotation at 0.151g/100ml of EtOH $[\alpha]_D^{22} = +37^\circ$) and 42 to 80 min for the second peak, corresponding to title enantiomer (ii) (optical rotation at 0.151g/100ml of EtOH $[\alpha]_D^{22} = +36^\circ$).

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CHIRACEL SEPARATION OF OTHER ENANTIOMERS OF THE INVENTION:

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(SiO₂) to afford the title compound as a pale yellow gum. δ_H (CDCl₃) 3.35 (2H, d, \underline{J} 8.0Hz, PhCHCH₂), 3.80 (3H, s, OMe), 3.86 (3H, s, OMe), 4.20 (1H, t, \underline{J} 8.0Hz, PhCHCH₂), 6.67 (1H, d, \underline{J} 2.0Hz, ArH ortho to OMe and CH), 6.7-6.8 (2H, m, ArH para to OMe+ArH ortho to OMe and meta to CH), 6.97 (2H, ca d, \underline{J} ca 5.0Hz, pyridine H₃, H₅), 7.15-7.35 (5H, m, C₆H₅), and 8.42 (2H, ca d, \underline{J} ca 5.0Hz, pyridine H₂, H₆); m/z (ESI) 342 (M⁺+Na, 21%), 320 (30), 228 (40), 227 (100), 213 (12), and 196 (12).

EXAMPLE 18

10 (±)-2-[2[(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzo[d]thiazole

Intermediate 19 (1.26g, 3.5mmol) in CH₂Cl₂ (6ml) was added to a stirred solution of 2-aminothiophenol (0.44g, 3.5mmol) in CH₂Cl₂ (8ml) and pyridine (2ml) at -70°C. The reaction mixture was stirred at -70°C for 20h, warmed to RT, concentrated in vacuo, and the residual brown oil subjected to chromatography (SiO₂; EtOAc-hexane, 1:1) to afford the title compound (826mg) as a pale green oil (Found: C, 75.15; H, 6.31; N, 3.30. C₂₇H₂₇NO₂S requires C, 75.49; H, 6.34; N, 3.26%); δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.78 (3H, s, OMe), 3.83 (2H, ca d, \underline{J} ca 8Hz, PhCHCH₂), 4.60 (1H, t, \underline{J} 8.0Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.7-6.85 (3H, m, C₆H₃), 7.1-7.45 (7H, m, C₆H₅+ benzothiazole H₅, H₆), 7.74 (1H, ca d, \underline{J} 8Hz, benzothiazole H₄ or H₇), and 7.95 (1H, ca d, \underline{J} ca 8Hz, benzothiazole H₄ or H₇).

25 EXAMPLE 19

(±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzaldehyde

NaOH (800mg, 20mmol) in water (20ml) was added to a solution of Intermediate 24 (2.46g, 4.87mmol) in EtOH (50ml) and the mixture heated to reflux for 1.5h. Concentrated hydrochloric acid was added to pH 4.5 and the mixture heated to reflux for 18h to complete the decarboxylation. The reaction mixture was concentrated to half-volume and partitioned between NaOH solution (0.5M; 100ml) and Et₂O (100ml). The organic layer was separated, washed with brine (25ml), dried (MgSO₄), and concentrated in vacuo to afford the title compound (1.80g) as a pale orange gum; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.35 (2H, ca d, \underline{J}

(SiO₂) to afford the title compound as a pale yellow gum. δ_H (CDCl₃) 3.35 (2H, d, \underline{J} 8.0Hz, PhCHCH₂), 3.80 (3H, s, OMe), 3.86 (3H, s, OMe), 4.20 (1H, t, \underline{J} 8.0Hz, PhCHCH₂), 6.67 (1H, d, \underline{J} 2.0Hz, ArH ortho to OMe and CH), 6.7-6.8 (2H, m, ArH para to OMe+ArH ortho to OMe and meta to CH), 6.97 (2H, ca d, \underline{J} ca 5.0Hz, pyridine H₃, H₅), 7.15-7.35 (5H, m, C₆H₅), and 8.42 (2H, ca d, \underline{J} ca 5.0Hz, pyridine H₂, H₆); m/z (ESI) 342 (M^+ +Na, 21%), 320 (30), 228 (40), 227 (100), 213 (12), and 196 (12).

EXAMPLE 18

10 (±)-2-[2[(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzo[d]thiazole

Intermediate 19 (1.26g, 3.5mmol) in CH₂Cl₂ (6ml) was added to a stirred solution of 2-aminothiophenol (0.44g, 3.51mmol) in CH₂Cl₂ (8ml) and pyridine (2ml) at -70°C. The reaction mixture was stirred at -70°C for 20h, warmed to RT, concentrated in vacuo, and the residual brown oil subjected to chromatography (SiO₂; EtOAc-hexane, 1:1) to afford the title compound (826mg) as a pale green oil (Found: C, 75.15; H, 6.31; N, 3.30. C₂₇H₂₇NO₂S requires C, 75.49; H, 6.34; N, 3.26%); δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 3.78 (3H, s, OMe), 3.83 (2H, ca d, \underline{J} ca 8Hz, PhCHCH₂), 4.60 (1H, t, \underline{J} 8.0Hz, PhCHCH₂), 4.63 (1H, br m, OCH), 6.7-6.85 (3H, m, C₆H₃), 7.1-7.45 (7H, m, C₆H₅+ benzothiazole H₅, H₆), 7.74 (1H, ca d, \underline{J} 8Hz, benzothiazole H₄ or H₇), and 7.95 (1H, ca d, \underline{J} ca 8Hz, benzothiazole H₄ or H₇).

25 EXAMPLE 19

(±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzaldehyde

NaOH (800mg, 20mmol) in water (20ml) was added to a solution of Intermediate 24 (2.46g, 4.87mmol) in EtOH (50ml) and the mixture heated to reflux for 1.5h. Concentrated hydrochloric acid was added to pH 4.5 and the mixture heated to reflux for 18h to complete the decarboxylation. The reaction mixture was concentrated to half-volume and partitioned between NaOH solution (0.5M; 100ml) and Et₂O (100ml). The organic layer was separated, washed with brine (25ml), dried (MgSO₄), and concentrated in vacuo to afford the title compound (1.80g) as a pale orange gum; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.35 (2H, ca d, \underline{J}

7.8Hz, CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.25 (1H, t, J 7.8Hz, CHCH₂ pyridine), 4.65 (1H, br m, OCH), 6.63 (1H, d, J 1.8Hz, ArH ortho to cyclopentyloxy), 6.70 (1H, dd, J 7.8, 1.8Hz, ArH para to OMe), 6.78 (1H, d, J 7.8Hz, ArH ortho to OMe), 6.92 (2H, ca d, J 6.7Hz, pyridine H₃, H₅), 7.35 (2H, d, J 8.3Hz, 2xArH meta to CHO), 7.79 (2H, d, J 8.3Hz, 2xArH ortho to CHO), 8.40 (2H, ca d, J 6.7Hz, pyridine H₂, H₆) and 9.97 (1H, s, CHO); m/z (ESI) 402 (M⁺ +1, 38%), 310 (22), and 309 (100). Treatment of the title compound (400mg) in Et₂O (40ml) with ethanolic HCl (2.5M) and concentration *in vacuo* afforded the title compound hydrochloride (420mg) as a yellow solid.

EXAMPLE 20

(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-hydroxymethylphenyl)ethyl]pyridine

Sodium borohydride (235mg, 6.21mmol) was added portionwise to the compound of Example 19 (1.11g, 2.85mmol) in EtOH (35ml) at -20°C. The suspension was allowed to warm to RT and stirred for 18h then treated dropwise with glacial acetic acid. The reaction mixture was concentrated *in vacuo* and the residue partitioned between Et₂O (50ml) and NaOH solution (1M; 50ml). The organic phase was separated, dried (MgSO₄) and concentrated *in vacuo* to afford the title compound (1.03g) as a colourless gum m.p. 179-182°C; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 2.4 (1H, v.br.s, CH₂OH), 3.31 (2H, d, J 7.9Hz, CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.15 (1H, t, J 7.9Hz, CHCH₂ pyridine), 4.65 (3H, sl.br.s, OCH+CH₂OH), 6.6-6.8 (3H, m, C₆H₃), 6.92 (2H, ca d, J 6.5Hz, pyridine H₃, H₅), 7.19 (2H, d, J 8.1Hz, 2xArH of C₆H₄), 7.26 (2H, d, J 8.1Hz, 2xArH of C₆H₄), and 8.35 (2H, ca d, J 6.5Hz, pyridine H₂, H₆); m/z (ESI) 404 (M⁺ +1, 35%), 312 (30), and 311 (100).

Treatment of the title compound (600mg) in Et₂O (50ml) with ethanolic HCl (2.5M), concentration *in vacuo* followed by recrystallisation (EtOH-Et₂O) afforded the title compound hydrochloride (602mg) as a white solid; δ_H (d₄-MeOH) 1.5-2.0 (8H, br m, (CH₂)₄), 3.72 (2H, d, J 8.1Hz, CHCH₂ pyridine), 3.76 (3H, s, OMe), 4.44 (1H, t, J 8.1Hz, CHCH₂ pyridine), 4.55 (2H, s, CH₂OH), 4.74 (1H, br m, OCH), 6.8-6.85 (3H, m, C₆H₃), 7.25-7.35

(4H, m, C₆H₄), 7.87 (2H, ca d, J 6.8Hz, pyridine H₃, H₅), and 8.62 (2H, ca d, J 6.8Hz, pyridine H₂, H₆) (N.B. CH₂OH and HCl not observed).

EXAMPLE 21

5 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-methoxymethyl-phenyl)ethyl]pyridine

The compound of Example 20 (400mg, 1.02mmol) in THF (10ml) was added to a suspension of NaH (60% dispersion in oil) (124mg, 3.09mmol) in THF (10ml) at 0°C then allowed to warm at RT over 0.5h. The mixture
10 was cooled to -20°C, treated with a solution of methyl iodide (98.4μl, 1.58mmol) in THF (5ml) and allowed to warm to RT. A further portion of methyl iodide (300μL, 4.8mmol) was added and the mixture allowed to stir at RT overnight then concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; EtOAc-hexane) to afford the title compound
15 (125mg) as a pale yellow gum; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.29 (2H, d, J 8.3Hz, CHCH₂ pyridine), 3.38 (3H, s, CH₂OMe), 3.80 (3H, s, OMe), 4.14 (1H, t, J 8.3Hz, CHCH₂ pyridine), 4.40 (2H, s, CH₂OMe), 4.63 (1H, br m, OCH), 6.6-6.8 (3H, m, C₆H₃), 6.92 (2H, ca d, J 6.5Hz, pyridine H₃, H₅), 7.18 (2H, d, J 8.2Hz, 2xArH of C₆H₄), 7.25 (2H, d, J 8.2Hz, 2xArH
20 of C₆H₄), and 8.39 (2H, ca d, J 6.5Hz, pyridine H₂, H₆); m/z (ESI) 419 (M⁺ +2, 15%), 418 (M⁺ +1, 45), 326 (33), and 325 (100).

Treatment of the title compound (100mg) in Et₂O (25ml) with ethanolic HCl (2.5M) then concentration *in vacuo* and recrystallisation (EtOH-Et₂O)
25 afforded the title compound hydrochloride (102mg) as an off-white solid m.p. 182-185°C; δ_H (d₄-MeOH) 1.5-1.9 (8H, br m, (CH₂)₄), 3.34 (3H, s, CH₂OMe), 3.71 (2H, d, J 8.3Hz, CHCH₂ pyridine), 3.75 (3H, s, OMe), 4.39 (2H, s, CH₂OMe), 4.43 (1H, t, J 8.3Hz, CHCH₂ pyridine), 4.73 (1H, br m, OCH), 6.75-6.85 (3H, m, C₆H₃), 7.25 (2H, d, J 8.3Hz, 2xArH of C₆H₄),
30 7.32 (2H, d, J 8.3Hz, 2xArH of C₆H₄), 7.84 (2H, ca d, J 6.7Hz, pyridine H₃, H₅), and 8.61 (2H, ca d, J 6.7Hz, pyridine H₂, H₆).

EXAMPLE 22

35 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-dimethylamino-methylphenyl)ethyl]pyridine

- Ethanolic HCl (2.5M) was added dropwise to dimethylamine (3.6ml of a 14% w/v solution in CH₃OH, 11.1mmol, 7.6eq) followed by the compound of Example 19 (570mg, 1.46mmol) in CH₃OH (5ml) and sodium cyanoborohydride (92mg, 1.46mmol) in one portion. The reaction mixture was stirred at RT for 24h then concentrated *in vacuo* and partitioned between EtOAc (25ml) and NaOH solution (2M). The organic layer was separated, dried (K₂CO₃), and concentrated *in vacuo* to give a pale brown gum which was subjected to chromatography (SiO₂; CH₃OH-CH₂Cl₂, 1:19) to afford the title compound (310mg) as a pale yellow gum; δ_H (CDCl₃; 250MHz) 1.5-2.0 (8H, br m, (CH₂)₄), 2.21 (6H, s, NM₂), 3.29 (2H, d, J 7.9Hz, CHCH₂ pyridine), 3.37 (2H, s, CH₂NMe₂), 3.79 (3H, s, OMe), 4.13 (1H, t, J 7.9Hz, CHCH₂ pyridine), 4.64 (1H, br m, OCH), 6.63 (1H, d, J 1.9Hz, ArH *ortho* to cyclopentyloxy), 6.68 (1H, dd, J 8.2, 1.9Hz, ArH *para* to OMe), 6.74 (1H, d, J 8.2Hz, ArH *ortho* to OMe), 6.92 (2H, ca d, J 6.0Hz, pyridine H₃, H₅), 7.13 (2H, d, J 8.2Hz, 2xArH of C₆H₄), 7.24 (2H, d, J 8.2Hz, 2xArH of C₆H₄), and 8.37 (2H, ca d, J 6.0Hz, pyridine H₂, H₆); m/z (ESI) 432 (M⁺+2, 30%), 431 (M⁺+1, 100), 338 (31), 294 (16), 226 (16), and 136 (9).
- Treatment of the title compound (310mg) in Et₂O (25ml) with ethanolic HCl (2.5M) and concentration *in vacuo* afforded the title compound dihydrochloride (360mg) as a pale yellow solid; δ_H (d₄-MeOH) 1.5-2.0 (8H, br m, (CH₂)₄), 2.82 (6H, s, CH₂NMe₂), 3.75 (5H, sl.br.s, OMe + CHCH₂ pyridine), 4.27 (2H, s, CH₂NMe₂), 4.52 (1H, t, J ca 8.0Hz, CHCH₂ pyridine), 4.78 (1H, br m, OCH), 6.8-6.9 (3H, m, C₆H₃), 7.4-7.6 (4H, m, C₆H₄), 7.88 (2H, ca d, J 6.7Hz, pyridine H₃, H₅), 8.63 (2H, ca d, J 6.7Hz, pyridine H₂, H₆) (N.B. HCl not observed).

EXAMPLE 23

- (±)-4-[1-(2-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzoic acid

- Aqueous sodium dihydrogen phosphate (5%; 15ml), then KMnO₄ (2.0g, 12.7mmol) in water (20ml), were added to a solution of the compound of Example 19 (1.50g, 3.85mmol) in t-butanol (25ml) at RT. After 0.25h, aqueous sodium sulphite solution (20ml) was added, the reaction mixture filtered through Celite®, the filter pad washed well with NaOH solution

(0.5M), and the filtrate concentrated *in vacuo*. The residue was partitioned between Et₂O (50ml) and water (50ml), the aqueous phase separated and acidified to pH 4 with concentrated hydrochloric acid. The mixture was cooled overnight at about 4°C, the precipitate filtered off and washed with water then Et₂O and dried *in vacuo* to afford the title compound (950mg, 61%) as a white solid m.p. 161-163°C; δ_H (d₄-MeOH) 1.5-1.9 (8H, br m, (CH₂)₄), 3.42 (2H, d, J 8.0Hz, CHCH₂ pyridine), 3.75 (3H, s, OMe), 4.35 (1H, t, J 8.0Hz, CHCH₂ pyridine), 4.70 (1H, br m, OCH), 6.7-6.85 (3H, m, C₆H₃), 7.18 (2H, d, J 6.7Hz, pyridine H₃, H₅), 7.38 (2H, d, J 8.3Hz, 2xArH *ortho* to CO₂H), 7.93 (2H, d, J 8.3Hz, 2xArH *ortho* to CO₂H), and 8.30 (2H, d, J 6.7Hz, pyridine H₂, H₆) (N.B. CO₂H not observed); m/z (ESI) 419 ($M^{+}+2$, 12%), 418 ($M^{+}+1$, 40), 326 (23) and 325 (100).

Treatment of the title compound (235mg) in Et₂O (25ml) with ethanolic HCl (2.5M), concentration *in vacuo* and recrystallisation (EtOH-Et₂O) afforded the title compound hydrochloride (224mg) as a white solid; δ_H (d₄-MeOH) 1.5-1.9 (8H, br m, (CH₂)₄), 3.75 (2H, d, J 8.0Hz, CHCH₂ pyridine), 3.75 (3H, s, OMe), 4.52 (1H, t, J 8.0Hz, CHCH₂ pyridine), 4.74 (1H, br m, OCH), 6.8-6.9 (3H, m, C₆H₃), 7.43 (2H, d, J 8.3Hz, 2xArH *meta* to CO₂H), 7.80 (2H, d, J 8.3Hz, 2xArH *ortho* to CO₂H), 7.88 (2H, d, J 6.7Hz, pyridine H₃, H₅), and 8.62 (2H, d, J 6.7Hz, pyridine H₂, H₆) (N.B. CO₂H and HCl not observed).

EXAMPLE 24

(±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl] benzamide

N-Methylmorpholine (163μL, 1.48mmol, 1.5eq) then isobutyl chloroformate (142μL, 1.09mmol, 1.1eq) were added to the compound of Example 23 (400mg, 1.00mmol) in THF-DMF (20ml; 3:1) at -20°C. Concentrated aqueous ammonia solution (1.0ml) was added, the mixture allowed to warm to RT overnight then concentrated *in vacuo*. The residue was partitioned between EtOAc (25ml) and NaOH solution (1M; 20ml). The organic layer was separated, washed with phosphate buffer (pH 7), dried (MgSO₄), and concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; CH₃OH-CH₂Cl₂, 1:19) to afford the title compound (245mg) as a pale yellow gum m.p. 180-182°C; δ_H (CDCl₃; 250MHz)

1.5-2.0 (8H, br m, (CH₂)₄), 3.32 (2H, d, J 7.9Hz, CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.20 (1H, t, J 7.9Hz, CHCH₂ pyridine), 4.64 (1H, br m, OCH), 5.6 (1H, v.br.s. CONH), 6.0 (1H, v.br.s. CONH), 6.63 (1H, d, J 2Hz, ArH ortho to cyclopentyloxy), 6.68 (1H, dd, J 8.2, 2.0Hz, ArH para to OMe), 6.76 (1H, d, J 8.2Hz, ArH ortho to OMe), 6.92 (2H, ca d, J 6.0Hz, pyridine H₃, H₅), 7.26 (2H, ca d, J 8.3Hz, 2xArH meta to CONH₂), 7.71 (2H, ca d, J 8.3Hz, 2xArH ortho to CONH₂) and 8.40 (2H, ca d, J 6.0Hz, pyridine H₂, H₆); m/z (ESI) 418 (M⁺+2, 15%), 417 (M⁺+1, 48), 325 (22), and 324 (100).

Treatment of the title compound (240mg) in Et₂O (25ml) with ethanolic HCl (2.5M), concentration *in vacuo*, and recrystallisation (EtOH-Et₂O) afforded the title compound hydrochloride (245mg) as a white solid; δ_H (d₄-MeOH) 1.5-2.0 (8H, br m, (CH₂)₄), 3.75 (2H, d, J 8.2Hz, CHCH₂ pyridine), 3.75 (3H, s, OMe), 4.54 (1H, t, J 8.2Hz, CHCH₂ pyridine), 4.76 (1H, br m, OCH), 6.8-6.9 (3H, m, C₆H₃), 7.44 (2H, d, J 8.4Hz, 2xArH meta to CONH₂), 7.88 (2H, d, J 6.7Hz, pyridine H₃, H₅), 7.94 (2H, d, J 8.4Hz, 2xArH ortho to CONH₂), and 8.63 (2H, d, J 6.7Hz, pyridine H₂, H₆) (N.B. CONH₂ and HCl not observed).

EXAMPLE 25

(±)-Ethyl 4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl] benzoate

Acetyl chloride (500μL) was added to EtOH (10ml) followed by the compound of Example 23 (385mg, 0.95mmol) and the resulting solution heated to reflux for 18h. The reaction mixture was concentrated *in vacuo* and the residue partitioned between aqueous sodium carbonate solution (2M; 10ml) and Et₂O (25ml). The organic layer was separated, dried (MgSO₄), concentrated *in vacuo* and the residue subjected to chromatography (SiO₂; EtOAc-hexane, 1:1 to 3:2) to afford the title compound (300mg) as a pale yellow gum m.p. 170-173°C; δ_H (CDCl₃) 1.39 (3H, t, J 7.5Hz, COCH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.32 (2H, d, J 8.0Hz, CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.20 (1H, t, J 8.0Hz, CHCH₂ pyridine), 4.30 (2H, q, J 7.5Hz, COCH₂Me), 4.62 (1H, br m, OCH), 6.65 (1H, d, J 2.0Hz, ArH ortho to cyclopentyloxy), 6.68 (1H, dd, J 7.8, 2.0Hz, ArH para to OMe), 6.78 (1H, d, J 7.8Hz, ArH ortho to OMe), 6.92 (2H, dd,

δ 5.2, 0.8 Hz, pyridine H_3, H_5), 7.25 (2H, d, δ 8.5 Hz, 2xArH *meta* to CO_2Et), 7.94 (2H, d, δ 8.5 Hz, 2xArH *ortho* to CO_2Et), and 8.40 (2H, dd, δ 5.2, 0.8 Hz, pyridine H_2, H_6); m/z (ESI) 447 ($M^+ + 2$, 20%), 446 ($M^+ + 1$, 63), 354 (27), 353 (100), and 285 (35).

5

Treatment of the title compound (295mg) in Et_2O (25ml) with ethanolic HCl (2.5M), concentration *in vacuo* and recrystallisation ($EtOH-Et_2O$) afforded the title compound hydrochloride (300mg) as an off-white solid; δ_H (d_4 -MeOH) 1.36 (3H, t, δ 7.2 Hz, $COCH_2Me$), 1.5-1.9 (8H, br m, $(CH_2)_4$), 3.73 (2H, d, δ 8.2 Hz, $CHCH_2$ pyridine), 3.76 (3H, s, OMe), 4.33 (2H, q, δ 7.2 Hz, $COCH_2Me$), 4.53 (1H, t, δ 8.2 Hz, $CHCH_2$ pyridine), 4.75 (1H, br m, OCH), 6.8-6.9 (3H, m, C_6H_3), 7.45 (2H, d, δ 8.4 Hz, 2xArH *meta* to CO_2Me), 7.84 (2H, d, δ 6.5 Hz, pyridine H_3, H_5), 7.94 (2H, d, δ 8.4 Hz, pyridine H_2, H_6), and 8.61 (2H, d, δ 6.5 Hz, pyridine H_2, H_6).

15

EXAMPLE 26

(±)-2-Chloro-4-[2-(3-cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine

A mixture of the compound of Example 6 (2.39g, 6.16mmol) and phosphorus oxychloride (25ml) was heated to reflux overnight. The reaction mixture was cooled to RT then carefully added to saturated potassium carbonate solution (250ml). Potassium hydroxide (2M) was added to pH 7.5 and the yellow-orange mixture extracted with $EtOAc$ (3x50ml). The extract was washed with brine (30ml), dried ($MgSO_4$), and concentrated *in vacuo* to give a red-brown gum which was subjected to chromatography (SiO_2 ; Et_2O -hexane, 1:1) to afford the title compound (1.16g, 46%) as a pale yellow gum; δ_H ($CDCl_3$) 1.5-2.0 (8H, br m, $(CH_2)_4$), 3.30 (2H, d, δ 8.0 Hz, $PhCHCH_2$), 3.80 (3H, s, OMe), 4.14 (1H, t, δ 8.0 Hz, $PhCHCH_2$), 4.66 (1H, br m, OCH), 6.68 (1H, d, δ 2.0 Hz, ArH *ortho* to cyclopentyloxy), 6.69 (1H, dd, δ 8.0, 2.0 Hz, ArH *para* to OMe), 6.76 (1H, d, δ 8.0 Hz, ArH *ortho* to OMe), 6.84 (1H, d, δ 6.5 Hz, pyridine H_5), 7.00 (1H, s, pyridine H_3), 7.05-7.3 (5H, m, C_6H_5), and 8.17 (1H, d, δ 6.5 Hz, pyridine H_6).

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EXAMPLE 27

(±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] aniline

Sodium iodide (210mg, 1.4mmol) and trimethylsilyl chloride (152mg, 1.4mmol) was added to the compound of Example 13 b (620mg, 1.27mmol) in acetonitrile (20ml) and the mixture stirred at RT for 1h. The reaction mixture was poured into 10% sodium thiosulphate solution (50ml) and extracted with CH_2Cl_2 (2x50ml). The extract was dried (MgSO_4), concentrated *in vacuo* and the residue subjected to chromatography (SiO_2 ; Et_2O) to afford the title compound (210mg) as a colourless gum; δ_{H} (CDCl_3) 1.5-1.9 (8H, br m, $(\text{CH}_2)_4$), 3.21 (2H, d, \downarrow 7.6Hz, PhCHCH_2), 3.44 (2H, br s, NH_2), 3.75 (3H, s, OMe), 4.14 (1H, t, \downarrow 7.6Hz, PhCHCH_2), 4.65 (1H, br m, OCH), 6.3-6.45 (3H, m, C_6H_3), and 6.6-7.4 (9H, m, $\text{C}_6\text{H}_5 + \text{C}_6\text{H}_4$); m/z (ESI) 410 ($\text{M}^+ + \text{Na}$, 30%), 388 ($\text{M}^+ + 1$, 60), 320 (58), 213 (23), and 196 (100).

EXAMPLE 28

15 (+)-Sodium 3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-1,2,4-triazolyl-5-thiolate

A mixture of thiosemicarbazide (0.43g, 4.7mmol) and Intermediate 19 (1.70g, 4.7mmol) in toluene (30ml) was heated to reflux for 4h. The reaction mixture was cooled, diluted with Et_2O (30ml) and the precipitate collected by filtration. The precipitate was washed with Et_2O then water to give a white solid, a portion of which (0.41g) was suspended in aqueous Na_2CO_3 (2M; 30ml) and heated to reflux for 4h. The cooled reaction mixture was diluted with water (20ml), acidified with 10% hydrochloric acid to pH5 and extracted with CH_2Cl_2 (2x40ml). The extract was dried (MgSO_4), concentrated *in vacuo*, and the residue recrystallised (CH_3OH) to afford the title compound (0.31g) as a white solid (Found: C, 62.97; H, 5.98; N, 10.02. $\text{C}_{22}\text{H}_{24}\text{N}_3\text{NaO}_2\text{S}$ requires C, 63.29; H, 5.79; N, 10.07%); δ_{H} (250MHz; $\text{DMSO}-d_6$) 1.5-2.0 (8H, br m, $(\text{CH}_2)_4$), 3.26 (2H, d, \downarrow 8.2Hz, PhCHCH_2), 3.67 (3H, s, OMe), 4.45 (1H, t, \downarrow 8.2Hz, PhCHCH_2), 4.72 (1H, br m, OCH), 6.7-6.85 (3H, m, C_6H_3), 7.1-7.35 (5H, m, C_6H_5), and 13.09 (1H, br s, NH); m/z (ESI) 419 ($\text{M}^+ + 1 + \text{Na}$, 35%), 418 ($\text{M}^+ + \text{Na}$, 67), 397 ($\text{M}^+ + 1$, 95), 396 (M^+ , 100), 328 (15), 204 (25), and 60 (81).

EXAMPLE 29

35 (-)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benzimidazole

Intermediate 19 (2.47g, 6.9mmol) in THF (10ml) was added dropwise to a solution of 1,2-diaminobenzene (3.72g, 34.4mmol) in THF (40ml) at 0°C and the mixture stirred for 2h. The reaction mixture was concentrated *in vacuo* and the residue washed with Et₂O (5x50ml). The extract was washed with 10% hydrochloric acid (50ml), sodium hydrogen carbonate solution (50ml), brine (50ml), then concentrated *in vacuo*. The residue was subjected to chromatography (SiO₂; EtOAc-hexane, 1:1) to give a pale brown glassy solid (1.02g), a portion of which (0.44g) was heated neat at 150°C for 60h then subjected to chromatography (SiO₂; Et₂O-hexane 1:1) to afford the title compound (273mg) as an off-white solid m.p. 97.5-98°C; δ_H (CDCl₃) 1.4-1.9 (8H, br m, (CH₂)₄), 3.6-3.7 (2H, m, PhCHCH₂), 3.78 (3H, s, OMe), 4.55 (1H, br m, OCH), 4.57 (1H, t, \downarrow 8Hz, PhCHCH₂), 6.7-6.8 (3H, m, C₆H₃), and 7.15-7.5 (9H, m, C₆H₅ + benzimidazole H₄, H₅, H₆, H₇); m/z (ESI) 413 ($M^{+} + 1$, 100%), 186 (48). (Optical rotation at 0.151g/100ml of EtOH [α]_D²² = -1).

EXAMPLE 30

a) (+)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]aniline Dihydrochloride Hemihydrate

A mixture of Intermediate 26 (3.80g), ammonium formate (1.63g), and 10% Pd/C (about 100mg) in EtOH (50ml) was heated to reflux for 2h then stirred at RT for 2 days. The reaction mixture was then filtered through Celite® and the filtrate concentrated *in vacuo*. The residue was partitioned between aqueous NaOH (1M; 50ml) and CH₂Cl₂ (50ml). The organic layer was separated, dried (Na₂SO₄), and concentrated *in vacuo*. The residue was dissolved in Et₂O (50ml) and treated with ethanolic HCl (2.5M) then concentrated *in vacuo*. The residue was recrystallised (EtOH-Et₂O) to afford the title compound (3.4g) as an off-white solid (Found: C, 63.97; H, 6.52; N, 5.77. C₂₅H₂₈N₂O₂. 2HCl.5H₂O requires C, 63.83; H, 6.64; N, 5.96%); δ_H (d₄-MeOH) 1.5-1.9 (8H, br m, (CH₂)₄), 3.7-3.85 (2H, m, CHCH₂ pyridine), 3.74 (3H, s, OMe), 4.56 (1H, t, \downarrow 8.8Hz, CHCH₂ pyridine), 4.75 (1H, br m OCH), 6.8-6.85 (3H, m, C₆H₃), 7.35 (2H, ca. d, \downarrow 8.5Hz, ArH of C₆H₄), 7.55 (2H, d, \downarrow 8.5Hz, ArH of C₆H₄), 7.91 (2H, d, \downarrow 6.6Hz, pyridine H₃, H₅) and 8.65 (2H, d, \downarrow 6.6Hz, pyridine H₂, H₆) (N.B. NH₂ and 2HCl not observed); m/z (ESI) 389 ($M^{+} + 1$, 11%), 297 (26), 296 (100), and 228 (11).

The following compound was prepared in a manner similar to the compound of Example 28a.

5 b) (±)-2-[4-(1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl)phenyl]-4,4-dimethyl-1,3-oxazoline, Dihydrochloride Dihydrate

From Intermediate 28b (0.27g, 0.56mmol), ammonium formate (0.70g, 11.2mmol) and 10% Pd/C (50mg). Chromatography (SiO₂; EtOAc) gave
10 the title compound free base (180mg) as a clear gum.

Dissolution of the title compound free base in Et₂O and treatment with ethereal HCl (1M) furnished the title compound as a white solid. (Found: C, 61.98; H, 6.53; N, 4.61. C₃₀H₃₄N₂O₃ · 2HCl · 2H₂O requires C, 62.17;
15 H, 6.96; N, 4.83%) δ_H (4-MeOH) 1.59 (6H, s, CMe₂), 1.6-1.9 (8H, br m, (CH₂)₄), 3.75 (3H, s, OMe), 3.7-3.9 (2H, m, CH₂-pyridine), 4.64 (1H, t, CHCH₂-pyridyl), 4.73 (1H, m, OCH), 4.77 (2H, s, CH oxazoliny), 6.8-6.9 (3H, m, C₆H₃), 7.68 (2H, d, J 8.4Hz, ArH meta to oxazoline), 7.90 (2H, d, J 6.6Hz, pyridine H₃, H₅), 8.01 (2H, d, J 8.4Hz, ArH ortho to oxazoline), and
20 8.65 (2H, d, J 6.5Hz, pyridine H₂, H₆); m/z (ESI) 471 (M⁺ + 1, 100%), 378 (67), and 245 (20).

EXAMPLE 31

25 (±)-Ethyl N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]carbamate

Ethyl chloroformate (81mg, 0.74mmol, 1.3eq) was added dropwise to a mixture of the compound of Example 30 (221mg, 0.57mmol) and triethylamine (75mg, 0.74mmol, 1.3eq) in CH₂Cl₂ (20ml). The reaction mixture was stirred overnight at RT, then concentrated *in vacuo* and the
30 residue subjected to chromatography (SiO₂; hexane/EtOAc, 1:1) to afford the title compound (170mg) as a white solid; δ_H (CDCl₃) 1.29 (3H, t, J 7.1Hz, OCH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.27 (2H, d, J 7.9Hz, CHCH₂ pyridine), 3.79 (3H, s, OMe), 4.10 (1H, t, J 7.9Hz, CHCH₂ pyridine), 4.20 (2H, q, J 7.1Hz, OCH₂Me), 4.64 (1H, br m, OCH), 6.51 (1H, br s, NH), 6.6-
35 6.8 (3H, m, C₆H₃), 6.92 (2H, d, J 5.9Hz, pyridine H₃, H₅), 7.11 (2H, d, J 8.4Hz, ArH of C₆H₄), 7.27 (2H, d, J 8.4Hz, ArH of C₆H₄), and 8.38 (2H, d,

δ 5.9 Hz, pyridine H₂, H₆); m/z (ESI) 461 (M⁺+1, 90%), 369 (25), and 368 (100).

EXAMPLE 32

5 (±)-N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]N'-ethylurea

A mixture of the compound of Example 30 (246mg, 0.63mmol) and ethyl isocyanate (68mg, 0.95mmol, 1.5eq) in CH₂Cl₂ (20ml) was stirred at RT for 2 days. A further portion of ethyl isocyanate (68mg, 0.95mmol, 1.5eq) was added and the mixture allowed to stir for 20h. The reaction mixture was concentrated *in vacuo* and the residue subjected to chromatography (SiO₂; EtOAc) to afford the title compound (221mg) as a white solid; δ _H (CDCl₃) 1.14 (3H, t, δ 7.2 Hz, OCH₂Me), 1.5-2.0 (8H, br m, (CH₂)₄), 3.2-3.35 (4H, m, CHCH₂ pyridine + OCH₂Me), 3.79 (3H, s, OMe), 4.11 (1H, t, δ 7.8 Hz, CHCH₂ pyridine), 4.59 (1H, br m, NHCONH), 4.66 (1H, br m OCH), 6.16 (1H, br s, NHCONH), 6.65-6.7 (2H, m, ArH *meta* to OMe), 6.75 (1H, d, δ 8.2 Hz, ArH *ortho* to OMe) 6.93 (2H, br m, pyridine H₃, H₅), 7.12 (2H, d, δ 8.6 Hz, ArH of C₆H₄), 7.18 (2H, d, δ 8.6 Hz, ArH of C₆H₄), and 8.39 (2H, br s, pyridine H₂, H₆); m/z (ESI) 460 (M⁺+1, 100%), and 117 (16).

EXAMPLE 33

25 (±)-N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]acetamide

Acetyl chloride (62mg, 0.79mmol, 1.3eq) was added dropwise to the compound of Example 30 (235mg, 0.60mmol) in CH₂Cl₂ (20ml) at 0°C and the mixture allowed to stir at RT overnight. The reaction mixture was concentrated *in vacuo* and the residue subjected to chromatography (SiO₂; CH₂Cl₂/MeOH, 9:1) to afford the title compound (140mg) as a white solid; δ _H (d₄-MeOH) 1.5-2.0 (8H, br m, (CH₂)₄), 2.09 (3H, s, COMe), 3.37 (2H, d, δ 8.2 Hz, CHCH₂ pyridine), 3.75 (3H, s, OMe), 4.23 (1H, t, δ 8.2 Hz, CHCH₂ pyridine), 4.69 (1H, br m OCH), 6.73 (1H, d, δ 1.9 Hz, ArH *ortho* to cyclopentyloxy), 6.77 (1H, dd, δ 8.2, 1.9 Hz, ArH *para* to OMe), 6.82 (1H, d, δ 8.2 Hz, ArH *ortho* to OMe), 7.15 (2H, d, δ 5.7 Hz, pyridine H₃, H₅), 7.21

(2H, d, J 8.6Hz, ArH of C₆H₄), 7.42 (2H, d, J 8.6Hz, ArH of C₆H₄), and 8.27 (2H, br s, pyridine H₂, H₆) (N.B. NH not observed); m/z (ESI) 431 ($M^+ + 1$, 100%), and 338 (22).

5 EXAMPLE 34

(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-furyl)-2-hydroxy-ethyl]pyridine

n-Butyllithium (1.6M solution in hexane; 16.9ml, 27mmol) was added to a stirred solution of furan (1.84g, 1.96ml, 27mmol) in THF (25ml) at -70°C. After 1h at -70°C, a solution of Intermediate 1 (4.0g, 18mmol) in THF (10ml) was added over 10 min. The reaction mixture was stirred at -70°C for 0.75h, warmed to RT over 0.75h, then quenched with water (100ml) and extracted with Et₂O (3x60ml). The extract was washed with brine (100ml), dried (MgSO₄), and concentrated *in vacuo*. The residual orange-yellow oil was subjected to chromatography (SiO₂; CH₂Cl₂/hexane, 3:1, then Et₂O/hexane, 1:1) to give (3-cyclopentyloxy-4-methoxyphenyl)(2-furyl)methanol (3.2g, 61%) as a colourless unstable oil; ν_{max} (neat) 3500cm⁻¹.

The alcohol (3.2g) was stirred with manganese (IV) oxide (10g) in CH₂Cl₂ (100ml) at RT for 3h. The mixture was filtered through Celite® and the filtrate concentrated *in vacuo*. The residual dark oil was subjected to chromatography (SiO₂) to give (3-cyclopentyloxy-4-methoxyphenyl)-(2-furyl)ketone (1.9g); ν_{max} (neat) 1620cm⁻¹.

n-Butyllithium (1.6M solution in hexanes; 4.2ml, 6.64mmol) was added to a solution of a 4-methylpyridine (0.62g, 0.65ml, 6.64mmol) in THF (25ml) at -70°C. After 0.5h, a solution of the crude ketone (1.9g, ca. 6.6mmol) in THF (5ml) was added, stirred for 1h at -70°C, then at RT for 0.25h. The reaction mixture was quenched with water (50ml) and extracted with EtOAc (3x50ml). The extract was dried (MgSO₄), concentrated *in vacuo*, and the residual red oil subjected to chromatography (SiO₂; EtOAc/hexane, 3:2) to afford the title compound (1.23g, 49%) as a pale yellow oil; δ_H (CDCl₃) 1.5-1.9 (8H, br m, (CH₂)₄), 2.84 (1H, br s, OH), 3.30 (1H, d, J 13.2Hz, CH_AH_B pyridine), 3.59 (1H, d, J 13.2Hz, CH_AH_B pyridine), 3.82 (3H, s, OMe), 4.65 (1H, br m OCH), 6.24 (1H, dd, J 3.3, 0.7Hz, furan H₃), 6.35 (1H, dd, J 3.3, 1.8Hz, furan H₄), 6.75-6.85 (3H, m, C₆H₃), 6.85 (2H, dd, J 4.5, 1.6Hz, pyridine H₃, H₅), 7.43 (1H, dd, J 1.8, 0.7Hz, furan H₅).

and 8.33 (2H, dd, J 4.5, 1.6 Hz, pyridine H_2 , H_6); m/z (ESI) 402 ($M^+ + 23$, 20%), 380 ($M^+ + 1$, 35), 287 (100), 95 (28), and 94 (97).

EXAMPLE 35

5 (+)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]benz[d]
oxazole

Bromobenzene (3.47g, 22.8mmol, 3.1equiv) was added to a stirred suspension of magnesium turnings (555mg, 22.1mmol, 3.0equiv) in THF (10ml) and the mixture stirred for 0.5h. A further portion of THF (30ml) was added and stirring continued for 1h. Copper (I) bromide-dimethyl sulphide complex (2.27g, 11.04mmol, 1.5equiv) was added to the Grignard solution at -70°C then allowed to quickly warm to -20°C. After 0.5h, the yellow-green slurry was cooled to -70°C and treated with a solution of Intermediate 37 (3.0g, 7.37mmol) in THF (10ml) over 10 min. After 2h at -70°C, the reaction mixture was warmed to -20°C over 0.5h then quenched with aqueous NH_4Cl solution (200ml) and extracted with EtOAc (150ml, 2x50ml). The extract was washed with NH_4Cl solution (40ml), and brine (50ml), then dried ($MgSO_4$), and concentrated *in vacuo*. The residue was triturated with Et_2O /hexane (1:2; 50ml) to afford (4S)-3-[3-(3-cyclopentyloxy-4-methoxyphenyl)-3-phenylpropanoyl]-4-phenyl-2-oxazolone (2.97g) as a white solid; δ_H ($CDCl_3$) 1.5-1.95 (8H, br m, $(CH_2)_4$), 3.6-3.85 (2H, m, CH_2CO), 3.79 (3H, s, OMe), 4.18 (1H, dd, J 8.7, 4Hz, $CHH'O$), 4.5-4.6 (1H, m, $CHCH_2CO$), 4.58 (1H, apparent t, J 8.7Hz, $CHH'O$), 4.70 (1H, br m, $ArOCH$), 5.32 (1H, dd, J 8.7, 4Hz, CHN), 6.75-6.8 (3H, m, C_6H_3), and 7.0-7.35 (10H, m, $2xC_6H_5$).

Hydrogen peroxide (27.5% w/w; 19.1g, 17.2ml, 155mmol) was added in small portions over 0.25h to a solution of the acyloxazolidinone (15.01g, 30.9mmol) in THF- H_2O (4:1, 240ml) at around 5°C. After a further 5 min, aqueous LiOH solution (1.0M; 43.5ml, 43.5mmol) was added dropwise at 0-5°C and the reaction mixture maintained at <5°C overnight.

Sodium sulphite solution (1.0M; 171ml) was added in small portions at <20°C and the THF removed *in vacuo*. The residue was filtered to remove any solid and the filtrate washed with EtOAc (2x100ml). The aqueous layer was acidified to pH2 and extracted with EtOAc (3x100ml). The extract was washed with brine (40ml), then dried ($MgSO_4$), and

concentrated *in vacuo* to afford 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-phenylpropanoic acid (10.2g) as a colourless viscous oil.

5 The crude carboxylic acid (3.19g, 9.38mmol) in CH_2Cl_2 (10ml) was treated with thionyl chloride (2.7ml, 37.5mmol) and the mixture heated to reflux for 3h. The reaction mixture was concentrated *in vacuo* and the residue azeotroped with toluene (2x25ml) to afford 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-phenylpropanoyl chloride (2.96g) as a brown oil.

10 A solution of the acid chloride (1.48g, 4.13mmol) in CH_2Cl_2 (5ml) was added to a suspension of 2-aminophenol (0.90g, 8.26mmol) in CH_2Cl_2 (15ml) and the mixture stirred for 2h. The reaction mixture was diluted with CH_2Cl_2 (100ml), washed with 10% HCl (2x25ml), then dried (Na_2SO_4), and concentrated *in vacuo*. The residue was subjected to
15 chromatography (SiO_2 ; EtOAc/hexane, 2:3) to afford an off-white foam (0.96g). The intermediate amide (400mg) was heated at 150°C for 60h and the residue subjected to chromatography (SiO_2 ; EtOAc/hexane, 1:4) to afford the title compound (234mg) as a white solid m.p. $91.5-92.5^\circ\text{C}$ (Found: C, 78.63; H, 6.68; N, 3.23. $\text{C}_{27}\text{H}_{27}\text{NO}_3$ requires C, 78.42; H, 6.58; N, 3.39%); δ_{H} (CDCl_3) 1.5-1.9 (8H, br m, $(\text{CH}_2)_4$), 3.64 (2H, d, J 8.1Hz, PhCHCH_2), 3.77 (3H, s, OMe), 4.61 (1H, br m, OCH), 4.74 (1H, t, J 8.1Hz, PhCHCH_2), 6.7-6.8 (3H, m, C_6H_3), 7.1-7.3 (7H, m, ArH), 7.4-7.45 (1H, m, ArH), and 7.6-7.65 (1H, m, ArH); ν_{max} (KBr) 2960, 1620, 1600, 1530, 1240, and 1140 cm^{-1} ; m/z (ESI) 436 ($\text{M}^+ + 23$, 100%), and 414 ($\text{M}^+ + 1$, 80); $[\alpha]_{\text{D}}^{22} = +64^\circ$ (0.167g/100ml EtOH).
20
25

EXAMPLE 36

5-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-1-methylimidazole

30 Methylamine was bubbled into a stirred mixture of Intermediate 39 (1.0g), 3\AA molecular sieves (ca. 5g), and 4-toluenesulphonic acid monohydrate (ca. 50mg). After stirring at RT for 1.5h, a few drops of Et_3N was added and the reaction mixture filtered using Et_2O washing. The filtrate was concentrated *in vacuo* to give the intermediate imine as a near colourless
35 oil (0.88g).

A mixture of the crude imine (0.88g), 1-butylamine (0.51ml), and (4-toluenesulphonyl)methyl isocyanide (TosMIC) (0.63g) in dimethoxyethane (30ml) was stirred at RT for 42h. The reaction mixture was then filtered and the filtrate partitioned between 20% HCl (50ml) and Et₂O (50ml). The aqueous layer was separated and combined with further 20% HCl extracts (2x25ml). The acid extract was washed with Et₂O (25ml), basified with solid KOH, then extracted with Et₂O (3x40ml). The organic extract was washed with brine (20ml), dried (MgSO₄), and concentrated *in vacuo*. The residual dark oil (0.6g) was subjected to chromatography (SiO₂; EtOAc to 2% MeOH-EtOAc) to afford the title compound (206mg) as a clear pale yellow oil; δ_H (CDCl₃) 1.5-2.0 (8H, br m, (CH₂)₄), 3.2-3.3 (5H, m, NMe + CHCH₂ pyridine), 3.80 (3H, s, OMe), 4.14 (1H, t, J 7.7Hz, CHCH₂ pyridine), 4.65 (1H, br m, OCH), 6.6-6.8 (4H, m, C₆H₃ + imidazole H₄), and 7.15-7.35 (6H, m, C₆H₅ + imidazole H₂); m/z (ESI) 377 (M⁺ + 1, 100%).

FORMULATION EXAMPLES

The compounds of the invention may be formulated for pharmaceutical use in a number of forms using any suitable excipients. Thus, for example, for oral use the compounds of the invention such as the compounds of the Examples may be formulated as a solid dosage form, by mixing an appropriate weight of compound (for example 50mg) with maize starch (50-99%w/w), anhydrous colloidal silica (0-10%w/w) and organic or inorganic acid (up to 1%w/w), to fill capsules of an appropriate size, e.g. white opaque hard gelatine capsules size 3. If desired the same mixture may be compressed into tablets.

The activity and selectivity of compounds according to the invention was demonstrated in the following tests. In these tests the abbreviation FMLP represents the peptide N-formyl-met-leu-phe.

Isolated Enzyme

The potency and selectivity of the compounds of the invention was determined using distinct PDE isoenzymes as follows:

- i. PDE I, rabbit heart
- ii. PDE II, rabbit heart
- iii. PDE III, rabbit heart, Jurkat cells
- iv. PDE IV, HL60 cells, rabbit brain, rabbit kidney and human
5 recombinant PDE IV
- v. PDE V, rabbit lung, guinea pig lung

A gene encoding human PDE IV has been cloned from human monocytes (Livi, *et al.*, 1990, *Molecular and Cellular Biology*, 10, 2678). Using similar
10 procedures we have cloned human PDE IV genes from a number of sources including eosinophils, neutrophils, lymphocytes, monocytes, brain and neuronal tissues. These genes have been transfected into yeast using an inducible vector and various recombinant proteins have been expressed which have the biochemical characteristics of PDE IV (Beavo
15 and Reifsnnyder, 1990, *TIPS*, 11, 150). These recombinant enzymes, particularly the human eosinophil recombinant PDE IV, have been used as the basis of a screen for potent, selective PDE IV inhibitors.

The enzymes were purified to isoenzyme homogeneity using standard
20 chromatographic techniques.

Phosphodiesterase activity was assayed as follows. The reaction was conducted in 150µl of standard mixture containing (final concentrations):
50mM 2-[[tris(hydroxymethyl)methyl]amino]-1-ethane-sulphonic acid (TES)
25 -NaOH buffer (pH 7.5), 10mM MgCl₂, 0.1µM [³H]-cAMP and vehicle or various concentrations of the test compounds. The reaction was initiated by addition of enzyme and conducted at 30°C for between 5 to 30 mins. The reaction was terminated by addition of 50µl 2% trifluoroacetic acid containing [¹⁴C]-5'AMP for determining recovery of the product. An aliquot
30 of the sample was then applied to a column of neutral alumina and the [³H]-cAMP eluted with 10ml 0.1 TES-NaOH buffer (pH8). The [³H]-5'-AMP product was eluted with 2ml 2M NaOH into a scintillation vial containing 10ml of scintillation cocktail. Recovery of [³H]-5'AMP was determined using the [¹⁴C]-5'AMP and all assays were conducted in the linear range of
35 the reaction.

Compounds according to the invention such as compounds of the Examples herein cause a concentration-dependent inhibition of recombinant PDE IV at 0.1 - 1000nM with little or no activity against PDE I, II, III or V at concentrations up to 100µM.

5

2. The Elevation of cAMP in Leukocytes

The effect of compounds of the invention on intracellular cAMP was investigated using human neutrophils or guinea pig eosinophils. Human neutrophils were separated from peripheral blood, incubated with dihydrocytochalasin B and the test compound for 10 min and then stimulated with FMLP. Guinea pig eosinophils were harvested by peritoneal lavage of animals previously treated with intra-peritoneal injections of human serum. Eosinophils were separated from the peritoneal exudate and incubated with isoprenaline and test compound. With both cell types, suspensions were centrifuged at the end of the incubation, the cell pellets were resuspended in buffer and boiled for 10 min prior to measurement of cAMP by specific radioimmunoassay (DuPont).

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The most potent compounds according to the Examples induced a concentration -dependent elevation of cAMP in neutrophils and/or eosinophils at concentrations of 0.1nM to 1µM.

3. Suppression of Leukocyte Function

Compounds of the invention were investigated for their effects on superoxide generation, chemotaxis and adhesion of neutrophils and eosinophils. Isolated leukocytes were incubated with dihydrocytochalasin B for superoxide generation only and test compound prior to stimulation with FMLP. The most potent compounds of the Examples caused a concentration-dependent inhibition of superoxide generation, chemotaxis and adhesion at concentrations of 0.1nM to 1µM.

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Lipopolysaccharide (LPS)-induced synthesis of tumour necrosis factor (TNF) by human peripheral blood monocytes (PBM) is inhibited by compounds of the Examples at concentrations of 0.01nM to 10µM.

4. Relaxation of Constricted Airway Smooth Muscle in vitro

The effects of compounds of the invention on guinea-pig isolated tracheal smooth muscle were investigated. Isolated tracheal rings were suspended in organ baths and immersed in oxygenated Krebs' solution. The smooth muscle was contracted with sub-maximal concentrations of histamine or carbachol prior to the addition of increasing concentrations of test compound to the organ baths. The most potent compounds of the Examples caused a concentration-dependent reversal of both histamine and carbachol-induced contractions at concentrations of 1nM to 100µM. The compounds were generally more potent in reversing histamine-induced tone than carbachol-induced tone.

5. Effects on Cardiac Muscle in vitro

Compounds of the invention have been tested for their effects on isolated cardiac muscle. Right atrial and papillary muscles were dissected out from the hearts of guinea pigs and suspended in organ baths for measuring the rate (chronotropic) of spontaneously beating atria and force (inotropic) of the electrically stimulated papillary muscle. In these preparations, selective PDE IV inhibitors such as rolipram do not have any direct effects whereas selective PDE III inhibitors such as milrinone have positive chronotropic and inotropic effects. The non-specific PDE inhibitor theophylline, which is used in asthma as a bronchodilator, also causes significant cardiovascular changes such as tachycardia. Selective PDE IV inhibitors have advantage over theophylline, therefore, through reduced cardiovascular side effects. The most potent and selective compounds of the Examples had no direct effects on the atrial and papillary muscles in vitro at concentrations up to 10µM but in combination with PDE III inhibitors, these inhibitors showed an enhancement of chronotropic and inotropic activity, typical of selective type IV inhibitors.

6. Anti-inflammatory Activity in vivo

Interleukin-5 (IL-5)-induced pleural eosinophilia in the rat (Lisle, *et al.*, 1993, *Br.J. Pharmacol.* 108, 230p) is inhibited by compounds of the Examples given orally at doses of 0.0001 to 10.0mg/kg. The most potent compounds cause a dose-dependent reduction in migrating eosinophils with ED₅₀s of 0.003 to 0.03mg/kg p.o.

Compounds of the invention also reduce the inflammatory responses induced in rats by platelet activating factor (PAF).

7. Anti-allergic Activity in vivo

Compounds of the invention have been tested for effects on an IgE-mediated allergic pulmonary inflammation induced by inhalation of antigen by sensitised guinea pigs. Guinea pigs were initially sensitised to ovalbumin under mild cyclophosphamide-induced immunosuppression, by intraperitoneal injection of antigen in combinations with aluminium hydroxide and pertussis vaccine. Booster doses of antigen were given two and four weeks later and at six weeks, animals were challenged with aerosolised ovalbumin whilst under cover of an intraperitoneally administered anti-histamine agent (mepyramine). After a further 48h, bronchial alveolar lavages (BAL) were performed and the numbers of eosinophils and other leukocytes in the BAL fluids were counted. The lungs were also removed for histological examination for inflammatory damage. Administration of compounds of the Examples (0.001-10mg/kg i.p. or p.o.), up to three times during the 48h following antigen challenge, lead to a significant reduction in the eosinophilia and the accumulation of other inflammatory leukocytes. There was also less inflammatory damage in the lungs of animals treated with compounds of the Examples.

8. Effects on Pulmonary Dynamics

Compounds of the invention (0.001-10mg/kg by oral or other route of administration) reduce the allergic bronchoconstriction caused by antigen in sensitized guinea pigs.

Compounds of the invention have been tested for their effects on ozone-induced hyperreactivity of the airways of guinea pigs. Following the inhalation of ozone, guinea pigs become very much more sensitive to the bronchoconstrictor effects of inhaled histamine than naive animals (Yeadon *et al*, 1992, *Pulmonary Pharm.*, 5, 39). There is a pronounced shift to the left (10-30 fold) of the dose response curve to histamine and a highly significant increase in the maximum increase in pulmonary resistance. Compounds of the Examples administered 1h prior to ozone by the intraperitoneal or oral (0.001-10mg/kg) route caused a dose-dependent inhibition of ozone-induced hyperreactivity.

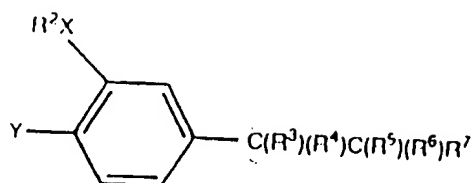
9. Adverse Effects

Compounds of the invention are free from adverse effects following repeated overdosage to rats or dogs. For example, over administration of 125mg/kg/day of active compounds of the Examples to rats for 30 days is not associated with adverse toxicity.

The most potent compounds of the invention are 20-30 times less active than rolipram in inducing behavioural changes, sedation or emesis in rats, ferrets or dogs.

CLAIMS

- 5 1. A compound of formula (1)



(1)

- 10 wherein Y represents a halogen atom or a group OR¹, where R¹ is an optionally substituted alkyl group;
 X is -O-, -S- or -N(R⁸)-, where R⁸ is a hydrogen atom or an alkyl group;
 R² is an optionally substituted alkyl, alkenyl, cycloalkyl or cycloalkenyl group;
 15 R³ is a hydrogen or halogen atom or an -OR⁹ group, where R⁹ is a hydrogen atom or an optionally substituted alkyl, alkenyl, alkoxyalkyl, or alkanoyl group, or a formyl, carboxamido or thiocarboxamido group;
 R⁴ and R⁵, which may be the same or different, is each a group
 20 -(CH₂)_nAr, where Ar is a monocyclic or bicyclic aryl group optionally containing one or more heteroatoms selected from oxygen, sulphur or nitrogen atoms and n is zero or an integer 1, 2 or 3;
 R⁶ is a hydrogen atom or an optionally substituted alkyl group;
 R⁷ is a hydrogen atom or an optionally substituted alkyl group; and
 25 the salts, solvates, hydrates and N-oxides thereof.
2. A compound according to Claim 1 wherein X is -O-.
3. A compound according to Claim 1 or Claim 2, wherein Y is a group
 30 -OR¹ where R¹ is a methyl group.
4. A compound according to any one of Claim 1 to Claim 3 wherein R² is a cyclopentyl group.

5. A compound according to any one of Claim 1 to Claim 4 wherein R³ is a hydrogen atom.
- 5 6. A compound according to any one of Claim 1 to Claim 5 wherein R⁶ and R⁷ is each independently a hydrogen atom or a methyl group.
7. A compound according to Claim 6 wherein R⁶ and R⁷ is each a hydrogen atom.
- 10 8. A compound according to Claim 1 wherein Y is a -OCH₃ group, X is -O-, R² is a cyclopentyl group, R³, R⁶ and R⁷ is each a hydrogen atom and R⁴ and R⁵ is each independently a group -Ar.
- 15 9. A compound according to Claim 8 wherein R⁴ is a group Ar where Ar is an unsubstituted or substituted monocyclic aryl or monocyclic heteroaryl group and R⁵ is a group Ar where Ar is an unsubstituted or substituted monocyclic nitrogen-containing heteroaryl group.
- 20 10. A compound according to Claim 9 wherein the monocyclic aryl group is an unsubstituted or substituted phenyl group, the monocyclic heteroaryl group is an unsubstituted or substituted furyl, thienyl or pyridyl group and the monocyclic nitrogen-containing heteroaryl group is an unsubstituted or substituted pyridyl, pyridazinyl, pyrimidinyl or pyrazinyl group.
- 25 11. A compound according to Claim 10 wherein the nitrogen-containing heteroaryl group is a substituted or unsubstituted pyridyl group.
- 30 12. A compound according to Claim 1 selected from:
(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-furyl)ethyl]pyridine;
(±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-thienyl)ethyl]pyridine;
35 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-3-methylimidazole;

- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]pyridine;
- 5 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-fluorophenylethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-trifluoromethylphenyl)ethyl]pyridine;
- 10 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(2-methoxyphenylethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-methoxyphenylethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-methylphenylethyl)]pyridine;
- 15 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(3-methylphenylethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(3-cyclopentyloxy-4-methoxyphenylethyl)]pyridine;
- (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]-3,5-dichloropyridine;
- 20 (±)-2-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]aniline;
- 25 (±)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzoic acid;
- (±) Ethyl N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]carbamate;
- (±) N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]N'-ethylurea;
- 30 (±)-N-[4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl]acetamide;
- (±)-3-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine;
- 35 (±)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyrimidine;

(±) -4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-hydroxymethyl-phenyl)ethyl]pyridine;

(±) -4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]benzamide;

(±) Ethyl-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-phenyl-ethyl)benzoate;

(±) N-(4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]phenyl)methanesulphonamide; or

the resolved enantiomers thereof; and the salts, solvates, hydrate and N-oxides thereof.

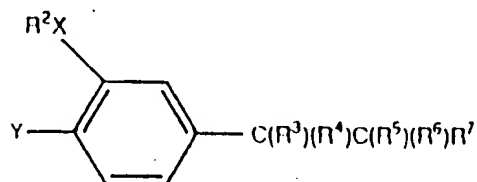
13. A compound according to Claim 1 which is (+)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl] pyridine; and the salts, solvates, hydrates and N-oxides thereof.

14. A compound according to Claim 1 which is (-)-4-[2-(3-Cyclopentyloxy-4-methoxyphenyl)-2-phenylethyl]pyridine; and the salts, solvates, hydrates and N-oxides thereof.

15. A compound according to Claim 1 which is (+)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]pyridine;

16. A compound according to Claim 1 which is (-)-4-[1-(3-Cyclopentyloxy-4-methoxyphenyl)-2-(4-pyridyl)ethyl]-pyridine;

17. A pharmaceutical composition comprising a compound of formula (1):



(1)

wherein Y represents a halogen atom or a group OR^1 , where R^1 is an optionally substituted alkyl group;

X is $-O-$, $-S-$ or $-N(R^8)-$, where R^8 is a hydrogen atom or an alkyl group;

R² is an optionally substituted alkyl, alkenyl, cycloalkyl or cycloalkenyl group;

R³ is a hydrogen or halogen atom or an -OR⁹ group, where R⁹ is a hydrogen atom or an optionally substituted alkyl, alkenyl, alkoxyalkyl, or alkanoyl group, or a formyl, carboxamido or thiocarboxamido group;

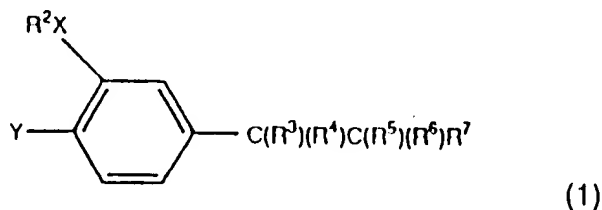
R⁴ and R⁵, which maybe the same or different, is each a group -(CH₂)_nAr, where Ar is a monocyclic or bicyclic aryl group optionally containing one or more heteroatoms selected from oxygen, sulphur or nitrogen atoms and n is zero or an integer 1, 2 or 3;

R⁶ is a hydrogen atom or an optionally substituted alkyl group;

R⁷ is a hydrogen atom or an optionally substituted alkyl group; and the salts, solvates, hydrates and N-oxides thereof

together with one or more pharmaceutically acceptable carriers, excipients or diluents.

18. A process for the preparation of a compound of formula (1):



wherein Y represents a halogen atom or a group OR¹, where R¹ is an optionally substituted alkyl group;

X is -O-, -S- or -N(R⁸)-, where R⁸ is a hydrogen atom or an alkyl group;

R² is an optionally substituted alkyl, alkenyl, cycloalkyl or cycloalkenyl group;

R³ is a hydrogen or halogen atom or an -OR⁹ group, where R⁹ is a hydrogen atom or an optionally substituted alkyl, alkenyl, alkoxyalkyl, or alkanoyl group, or a formyl, carboxamido or thiocarboxamido group;

R⁴ and R⁵, which maybe the same or different, is each a group -(CH₂)_nAr, where Ar is a monocyclic or bicyclic aryl group optionally

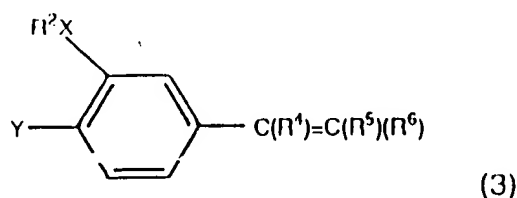
containing one or more heteroatoms selected from oxygen, sulphur or nitrogen atoms and n is zero or an integer 1, 2 or 3;

R⁶ is a hydrogen atom or an optionally substituted alkyl group;

R⁷ is a hydrogen atom or an optionally substituted alkyl group; and

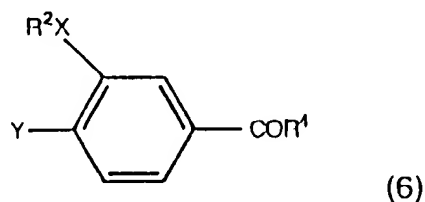
5 the salts, solvates, hydrates and N-oxides thereof which comprises in a final step

a) the hydrogenation of a compound of formula (3):



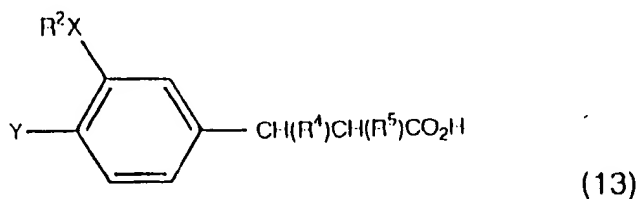
wherein Y, X, R², R⁴, R⁵, and R⁶ are as defined for formula (1), to yield a compound of formula (1) wherein R³ and R⁷ is each a hydrogen atom; or

15 b) the reaction of a ketone of formula (6):



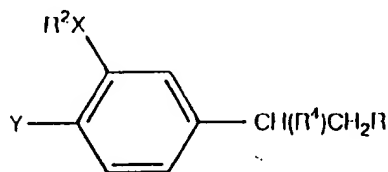
20 wherein Y, X, R² and R⁴ are as defined for formula (1), with an organometallic reagent R⁵R⁶CHZ where R⁵ and R⁶ are as defined for formula (1) and Z is a metal atom, to yield a compound of formula (1) wherein R³ is a hydroxyl group and R⁷ is a hydrogen atom; or

c) the decarboxylation of an acid of formula (13):



wherein Y, X, R², R⁴ and R⁵ are as defined for formula (1) to yield a compound of formula (1) wherein R³, R⁶ and R⁷ is each a hydrogen atom; or

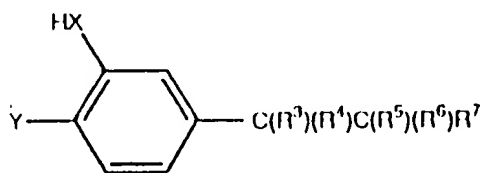
- d) the cyclisation of a compound of formula (15):



(15)

wherein Y, X and R⁴ are as defined for formula (1) and R is a carboxylic acid [-CO₂H] group or a reactive derivative thereof, a nitrile [-CN] or an imine salt, with a bifunctional reagent W¹R^{5a}W² and where necessary a compound R^{5b}W³ [where W¹, W² and W³, which may be the same or different, is each a reactive functional group or a protected derivative thereof; and R^{5a} and R^{5b} are components of the heteroaryl group R⁵ such that when added together with W¹, W² and W³ to the group R in compounds of formula (15) the resulting group -RW¹R^{5a}W² or -RW¹R^{5a}W²R^{5b}W³ constitutes the heteroaryl group R⁵], to yield a compound of formula (1) wherein R³, R⁶ and R⁷ is each a hydrogen atom and R⁵ is a heteroaryl group; or

- e) the alkylation of a compound of formula (18):



(18)

wherein Y, X, R³, R⁴, R⁵, R⁶, and R⁷ are as defined for formula (1) with a reagent R²L wherein R² is as defined for formula (1) and L is a leaving group; or

- f) the interconversion of a compound of formula (1) to another compound of formula (1), or
g) by reaction of a compound of formula (1) with an acid or base to yield a salt of a compound of formula (1);

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/GB 93/02625A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 C07C43/253 A61K31/44 C07C43/235 C07D213/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 C07C C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOURNAL OF THE INDIAN CHEMICAL SOCIETY vol. 58, no. 3, 1981 P.B. SATTUR ET AL. 'SYNTHESIS AND PHARMACOLOGY OF 2,5-DISUBSTITUTED 1,3,4-OXADIAZOLES' see examples 9,14,15 ---	1-18
X	CHEMICAL ABSTRACTS. REGISTRY HANDBOOK - NUMBER SECTION. PRINTED ISSUES COLUMBUS US * compounds with registry numbers 95992-21-5; 95971-60-1; 90053-37-5; 82668-18-6; 80395-25-1; 49610-49-3 ---	1
A	US,A,5 128 358 (N.A. SACCOMANO AND F.J. VINICK) 7 July 1992 ---	
A	WO,A,92 19594 (SMITH-KLINE BEECHAM CORPORATION) 12 November 1992 ---	

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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

4 March 1994

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/GB 93/02625

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO-A-9219594	12-11-92	AU-A- 1917092	21-12-92
		CN-A- 1067244	23-12-92
		EP-A- 0584208	02-03-94
US-A-4971959	20-11-90	US-A- 5274002	28-12-93
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		EP-A- 0523138	20-01-93
		JP-T- 6500071	06-01-94

